MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

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PROFESSOR CAYLEY, President, in the Chair.

S. J. Lambert, Esq. Auckland, New Zealand,

was balloted for and duly elected a Fellow of the Society.

The President announced, soon after the Meeting commenced, that the Astronomer Royal, at the suggestion of the Board of Visitors at Greenwich, had applied to Government for the means of organising parties of observers in the Southern Ocean, with the view of finding additional localities in the sub-Antarctic regions for observing the whole duration of the Transit of *Venus*.

The Rev. J. V. Mummery, at the same Meeting, presented to the Society a fine Photograph from a painting of the late Mrs. Somerville.

Notes on Star-Guaging.

By Richard A. Proctor, B.A. (Cambridge).

As several telescopists have expressed a wish to take part in the work of star-guaging, and to be informed as to the best way of making their work effective, I venture to give a few hints on the subject.

In the first place, it is to be noted that the main object of the proposed method of observation is to obtain complete general sur-

veys of the heavens with various apertures. It is the direct result of the researches which I have already made, that mere random star-guaging will not suffice to give just views of the structure of the sidereal system ; that, on the contrary, such a process is more likely to prove deceptive than useful. What is wanted is a survey which shall include the whole heavens (eventually), or at the beginning shall include the whole of each region surveyed, without gaps or interstices. But the extent of such a survey renders it absolutely necessary that it should be conducted in a manner the least elaborate that can be devised, so only that no essential details be neglected. To *map* the whole heavens with telescopes of considerable light-gathering power would require an army of observers where only a few volunteers are available; moreover, such mapping, while having a high value in other ways, would be less instructive regarded as star-guaging than a survey conducted by a few observers, each taking a considerable area. For the different powers of the observers engaged would cause noteworthy differences in the apparent numerical distribution of stars, and such apparent differences would be confounded with the real varieties of distribution which it is the object of the star-guaging to discover.

As respects the first point, completeness, I may remark that I have obtained very striking evidence on that subject. For the winter before last, with the $4\frac{7}{10}$-inch Sheepshanks belonging to the Society, I surveyed the region of the heavens included in the parts of *Taurus* north of 15° North Dec., using circular guage-fields, touching each other in R.A. Now, the results of the guaging thus conducted were so far interesting that they indicated in a very marked manner the prolongation (with increase of telescopic range) of that remarkable region poorly strewn with stars, which is shown in this part of the heavens in my chart of 324,000 stars. But on commencing the re-examination of this part of the heavens with the same telescope and eye-piece, but a field reduced to the figure of a square, I found a marked difference in the result as respects many details, though the general distribution was not very different.*

As respects the method to be employed, I think the following notes may be useful:—

A square field is the most convenient, and the side of the square may conveniently correspond to 15′ of a great circle. But this is not important—the field need not have any special size. An edge of the square should of course lie on a parallel of declination. The guaging eye-piece should be of rather low power, but not too low, especially with large instruments. The most suitable power will be indicated by what I have said as to the size of the field, if the diaphragm used to reduce the field be such as to give

* I had proposed to resume the survey with the same telescope (using square fields) this year. But having had one of Mr. Browning's $12\frac{1}{4}$-inch reflectors placed at my disposal by Lord Lindsay, I naturally prefer to devote my time to a deeper survey.

a square not much less than the inscribed square within the original circular field. On this point, however, little need be said, as in fact each observer can consider his own convenience, and so long as the nature of the eye-piece and size of field are indicated in the guage-book (together, of course, with the aperture of telescope, &c.), no difficulty will arise.

The most important point is the way of taking and recording guages. The work must be done in the dark, except when a new sweep is to be commenced. Therefore the observer should provide a number of squares of paper (or preferably card) to be strung on a cord, and mark in, in pencil, the number of stars counted in each field, passing each paper when thus marked from the set of unused papers to those already marked.

When a sweep begins the telescope (clamped of course in declination) is directed to the western extremity of the proposed sweep. The number of stars in the field is counted rapidly, and the telescope is moved eastwards until the western edge of the new field corresponds (as nearly as can be judged by estimation) with what had been the eastern edge of the former field. The process is repeated, field after field, until the proposed range of sweep has been completed (so nearly as can be judged). Thus, say the width of each field is 20′ in R.A., and that the observer desires to range 15° in R.A., he would count in this way 45 fields (or say two or three more to ensure the completion of the desired range). He must now determine the exact distance he has swept over, either in the regular way, when he has a suitable clock, or by noting the apparent difference of R.A., as indicated by the R.A. circle adding so much as corresponds to the time occupied in sweeping. The necessity for this process is obvious, when it is remembered that the shift from field to field has been made by estimation only, and *can* only be so made, except by methods which would involve delay and inconvenience. Thus the fields may slightly overlap, or there may be slight gaps (though no star can escape being counted), and the real range in R.A. may be several minutes less or greater than would be judged from the number of fields. But knowing the exact range of the sweep, and in the guage maps (afterwards to be constructed) dividing that range into so many equal parts as there were fields, no error of the least importance can accrue. The numbered papers should then be removed, with a portion of the string, this being tied round them, so that these papers may remain unchanged in order. The telescope must then be returned to its former position in R.A., that is the first field brought again into view, in doing which the range of R.A. can again be noted, if any doubt be felt as to the former determination. Then the telescope must be shifted in declination until a field north or south of the first is in view. This will, of course, be done in the usual way, by means of the declination-circle, since the exact size of the field is known. Another sweep will then be taken in the same way as the former. And the process may be repeated as

long as the observer cares to remain at work. Care must, of course, be taken to keep the successive strings of guage papers distinct. This is readily effected by simply marking the first paper on each string with the declination of the central line of the sweep.

Note on the Possible Existence of a Lunar Atmosphere.

By E. Neison, Esq.

Owing to the many difficulties with regard to the constitution of the lunar surface involved in an assumption as to the absolute non-existence of a lunar atmosphere, it would appear of far greater probability that some such atmosphere, however limited, exists. Not only, as Dr. De La Rue has remarked, is it difficult to conceive any chemical formation of matter without an atmosphere ; but it is also difficult to even find matter, exhibiting the features and properties of that constituting the lunar surface, which under the known conditions would not either yield an atmosphere, or require for formation the presence of substances that would.

The absolute absence of any atmosphere has never yet been demonstrated, but only the fact that it does not exceed certain limits, generally supposed much more restricted than is actually the case. In consequence, it is usually granted that some atmosphere might exist ; it is also assumed that it must be of most extreme tenuity ; and the subject is dismissed as a matter of indifference without inquiring where the admission might carry us in so far as relates to this atmosphere's power of fulfilling the same purposes as our own terrestrial one.

But it would be of interest to ascertain how far this possible lunar atmosphere might not effect for the lunar surface those changes, &c., that our own does for the terrestrial surface ; and whether, in fact, it might not amply suffice for maintenance of, at least, some form of vegetable life. For the present, however, this must be deferred.

The only point restricting the extent of a lunar atmosphere of the nature supposed, appears to be its refractive power, more especially as shown by the occultation of stars by the Moon. Irrespective of the circumstance that these do not invariably answer conclusively in the negative, it does not appear to be generally recognised, that we may have an atmosphere whose maximum power of refraction would not be equal to one second of arc, and yet be of very considerable amount. For of however great tenuity, in comparison with our dense terrestrial atmosphere, it would be in reality present in large quantity ; to be estimated, in fact, with regard to each square mile of surface, by very many thousands of tons.

There can be but little doubt but that such an atmosphere

would exert a very considerable influence on the lunar surface; render possible the existence of many substances that appear to constitute a great portion of that surface; and explain many selenographical observations of great interest, that at present appear to point to some such solution, and thus support the hypothesis of the existence of a definite lunar atmosphere.

10*th June*, 1873.

On the Determination of Longitudes by Moon Culminations.

By Asaph Hall, Esq.

(*Communicated by J. W. L. Glaisher, Esq.*)

The method of determining longitudes by Moon culminations is so simple in theory and so easy of application, that when only an approximate value of the longitude is desired, this method will often be applied. In case, however, we wish an accurate determination of a geographical position, such as may be necessary for a station occupied in observing the Transit of *Venus*, it is well that we should not over-estimate the accuracy of this method. In many of the estimates that have been made we have an illustration of what is frequently happening, viz. the oversight of the existence of constant errors which render such estimates of accuracy wholly illusory. It is customary to determine the probable error of observing the transit of the Moon's limb over a single wire, by comparing the transits among themselves, to do this also for a fixed star, and then by combining these probable errors to determine the probable error of the observed difference of right ascension. Performing this calculation for the two stations, we have, by known rules, the probable error of the resulting longitude; and if our assumptions were correct, we could, by increasing the number of observations, reduce the error of the longitude to as small a quantity as we please. Experiment, however, shows that this is impossible. In nearly all the determinations of longitude by Moon culminations, where a large number of culminations have been observed, the computed probable error of the result is only a small fraction of a second; but the telegraphic determinations of the same points show errors in the old determinations of two, three, and even four seconds of time. Thus the longitude of San Francisco, determined from 206 Moon culminations, was found to be four seconds in error. The most decisive experiment on this point is the determination of longitude between Europe and America. The three determinations of longitude between Greenwich and Washington by the U. S. Coast Survey, by means of the Atlantic cables, give the difference of longitude, $5^h\ 8^m\ 12^s.2$. The following are the determinations of the same difference of longitude by Moon culminations:

Authority.	No. Culminations.	Longitude.	Error.
		h m s	s
Loomis	150	5 8 9·3	− 2·9
Gilliss	394	5 8 10·0	− 2·2
Walker	..	5 8 9·6	− 2·6
Newcomb	279	5 8 11·6	− 0·6
Newcomb	163	5 8 9·8	− 2·4

In his last determination Professor Newcomb used the observations of 1862 and 1863, when the transits both at Greenwich and Washington were recorded by the chronographic method. It seems, therefore, fair to conclude that a longitude determined by Moon culminations may be in error two or three seconds, even if we could use an infinite number of observations.

In 1855 and 1856 an attempt was made at Cambridge, Massachusetts, by Professors Bond and Peters, to determine the difference of longitude between the observatories of Harvard College and Cloverden by observing Moon culminations. In order to secure greater accuracy in the result, a well-defined spot in the Moon, *Messier*, was observed instead of the Moon's limb. It was found that the transits of this spot could be observed with as much accuracy as those of a fixed star. The resulting difference of longitude was $3^{s}\cdot54$, while the triangulation gave $1^{s}\cdot65$, showing an error of nearly two seconds in the longitude, arising from the presence of some constant error in the observations.

The results of the chronometric expeditions conducted by Struve, Airy, and Bond, show that longitudes determined in this manner are decidedly superior in accuracy to those found from the observations of Moon culminations. The values of the difference of longitude between Greenwich and Washington found by Professor Bond are as follows :

	Longitude.		Error.
	h m s	s	s
1849, '50	5 8 11·6	±0·29	− 0·6
1851	5 8 11·9	±0·25	− 0·3
1855	5 8 13·0	±0·19	+ 0·8

In conclusion, I remark that, so far as I have seen, nearly all the determinations of longitude between Greenwich and Washington which have been derived from Moon culminations, occultations of stars by the Moon, and solar eclipses, give the difference of longitude *smaller* than the telegraphic value, $5^{h}\ 8^{m}\ 12^{s}\cdot2$, which I have assumed to be the true value.

Washington, 1873, *May* 1.

Note on Dr. Oudemans' Photographs of the Solar Eclipse of December 11–12, 1871. By Lieut-Col. Tennant, R.E.

I am indebted to Dr. A. C. Oudemans of Batavia for copies of two photographs taken by Mr. Dietrichs at Buitenzorg, in Java.

These consist of two paper proofs from the original negatives and two transparent enlargements on glass. In the negatives the diameter of the lunar disk is about 3 m.m., so that the equivalent focus of the lens must have been about 41 c.m., or 16 inches. Dr. Oudemans describes it as No. 10 C by Liesegang, of Elberfeld. The exposure in each case was half a second, and the glass enlargements show that the amount of corona depicted was not very materially less than in the photographs at Dodabetta and Bekul. The Moon's limb is, however, very sharp, and the small negative has borne enlargement to a lunar diameter of 2 c.m., with singularly little loss of definition of the dark edge ; which, too, is very free from halation or encroachment from the prominences. In the transparencies sent me, however, there is very much less detail in the corona than in the Indian photographs.

The principal thing to be noted is the very complete resemblance of the general form of the corona in the Java photographs and in our Indian ones, though there was an hour of difference in absolute time. I can recognise almost every depression of outline, and the form and relative sharpness of the edges of the southern rift, and even of the less definite northern one, are very markedly similar. I presume no one now believes the corona to be an atmospheric phenomenon ; but these photographs show a considerable amount of permanence in its features, and it would be very interesting to compare the original negatives, for which purpose perhaps those of Mr. Dietrichs could be procured.

I think we learn something, too, as to photography in this application from these photographs.

1st. It is evident that the great altitude of the Sun, and probable clearness of the air at Buitenzorg, allowed an exposure of half a second to impress nearly as much image as the long exposures which we gave in India. I cannot here get the aperture of the lens ; but, assuming it to have been a portrait lens of the focal length I have named and of the usual construction, the intensity of the light would have been about four times as great as with the lenses used in India.

Next, it is evident that this more intense light acting only for a short time has not had the tendency to produce halation which the longer exposure produced. This is quite, I think, in accordance with ordinary photographic experience ; halation was first conspicuous in dry plates requiring long exposure, and I have prints from my own work in which there are clouds brilliantly illuminated by the Sun setting behind them, and which relieve foliage in the foreground without halation or blurring.

Comparing these photographs with ours at Dodabetta and those taken at Bekul, I am disposed to think that no reasonable

exposure of the plates could have given us so enormous an extension of the corona, as appears to have been obtained by Mr. Brothers at Syracuse in 1870.*

It must now, too, be evident that, as I have all along held, the want of illuminating power in the silver glass reflector was not the cause of the absence of corona from the photographs of 1868. The whole surface of glass in the rectilinear lens does not concentrate light on the point of the image ; but did it do so, we should have as the relative illumination 143·1 for the mirror and 161·6 for the lens. Allowing for a portion of the lens being non-effective, and reflexion at four transmitting surfaces as compared with two reflexions on silver well polished, the instruments used in India in 1868 and 1871 should not be far from equal.

The Buitenzorg pictures show that a fifth of the exposure given at Dodabetta would, with a high sun and clear sky, have produced about equal effects, and the conclusion seems to me absolutely inevitable that the real cause of the absence of corona in 1868 was the haze to which I ascribed it.

I consider this of very great importance, because the large image given by the telescope, as used in 1868, is an enormous gain ; and I am convinced that in photographing the corona in any future eclipse it will be every way desirable to use a reflector, or a lens of similar size, and the former is much cheaper, while the ratio of aperture to focal length can be increased even beyond that of the telescope I had in 1868, which would, I imagine, be difficult in a lens.

I think such photographs should be sought in the next attempt to observe a total eclipse, and care should be taken to have the Sun high.

May 14th, 1873.

Observations of the Partial Solar Eclipse of May 25, made at Forest Lodge, Maresfield. By Capt. Noble.

At the precise instant of first contact the whole sky was covered with clouds ; but, looking through the finder of my equatoreal at $23^h\ 53^m\ 10^s$ L.S.T. $= 19^h\ 37^m\ 23^s{\cdot}6$ L.M.T. I caught a glimpse of part of the Sun's limb through a little gap ; and saw that the Moon had then fairly and perceptibly entered on to it.

At $0^h\ 47^m\ 40^s$ L.S.T. $= 20^h\ 31^m\ 44^s{\cdot}7$ L.M.T., the eclipse being, as I assume, just past its greatest phase, the ruggedness of the Moon's Southern limb was very noticeable; a sierra or chain of mountains about south, and an isolated one to the west of them, I took to belong to the Dörfel and Leibnitz Mountains.

At $1^h\ 32^m\ 40^s$ L.S.T. $= 21^h\ 16^m\ 37^s{\cdot}3$ L.M.T. I could *just* trace the Moon's limb for a very few seconds beyond the Sun's disk ; it was a shade lighter than the sky.

* Mr. Brothers' photograph seems to differ from all those of 1871 in showing nearly all the corona on *one* side.

I fortunately observed the last contact through a perfectly clear gap. It occurred at $1^h\ 38^m\ 27^s{\cdot}2$ L.S.T. $= 21^h\ 22^m\ 23^s{\cdot}5$ L.M.T. I do not fancy that this determination is 1^s in error.

I employed a power of 74, with a red eye-shade; on my 4·2-inch Ross equatoreal, the cloud and mist obviating all necessity for the use either of a reflecting eye-piece or of a constricted aperture.

My latitude and longitude are approximately $51^\circ\ 0'\ 58''$ N. and $17^s{\cdot}5$ E.

Forest Lodge, Maresfield, Sussex,
June 12, 1873.

Partial Solar Eclipse of May 25, 1873.
By the Rev. S. J. Perry.

During the greater part of this eclipse the sky was perfectly clear, but thick clouds obscured the Sun during the remainder of the morning.

Six photographs were taken of the successive phases, and the instant of exposure noted by a Frodsham chronometer. The first picture was taken when the Moon had sufficiently advanced on the Sun's limb to admit of accurate measurement, and it was intended to complete the series with a photograph of the shadow a minute before last contact; but the clouds interfered towards the end. A diameter of 121·5 millimetres was chosen as the most convenient under the circumstances for the photographs.

The following are the results obtained, the unit of length being the solar diameter:—

No.	G.M.T.	Dist. between Cusps.	Magnitude.
	h m s		
1	7 38 41·7 a.m.	0·112	0·0063
2	7 50 16·9	0·513	0·142
3	8 7 43·0	0·730	0·317
4	8 21 1·1	0·791	0·388
5	8 32 35·7	0·825	0·435
6	8 44 29·1	0·756	0·345

Stonyhurst Observatory,
June 5th, 1873.

The Total Solar Eclipse of June 14th, 2151.
By J. Maguire, Esq.

In the *Monthly Notices* for December last I stated that, from elements which I considered doubtful, I had made a calculation which placed the central line of this eclipse to the north of Norwich. Since that time I have derived the places of the Sun

and Moon from the Tables of Leverrier and Hansen, obtaining the following elements :

		d	h	m	s
G. M. T. of ☌ in R.A.	..	June 14	5	14	0
Sun and Moon's R.A.	..		5	31	32·6
			°	′	″
Moon's Declination N.	..		23	55	26·8
Sun's ,, N.	..		23	15	29·6
Moon's Hor. Mot. in R.A.	..			40	2
Sun's ,, R.A.	..			2	35·6
Moon's ,, Decl. N.	..			5	8
Sun's ,, Decl. N.	..				7
Moon's Equa. Hor. Parallax	..			60	20·6
Sun's ,, ,,	..				8·8
Moon's True Semidiameter	..			16	28·1
Sun's ,,	..			15	45·6

I have taken the sidereal time at Greenwich mean noon at $5^h\ 30^m\ 5^s$, and the obliquity of the ecliptic at $23°\ 15'\ 11''$.

By direct calculation I find that Ayr, Penrith, York, and Cromer, are on the central line. Edinburgh is within the northern limit of totality ; while Warrington, Derby, and Cambridge, are on the southern limit. The width of the zone of totality is 140 miles.

Whatever confidence I may have as to the accuracy of these elements, and the position of the central line, I cannot lose sight of the fact that they differ materially from those given by Mr. Hind in the *Monthly Notices* for January.

Norwich, June 1873.

Note explanatory of a Stereographic Projection of the Transit of 1882. By Richard A. Proctor, B.A., Cambridge.

It seems to me very desirable, in considering what preparations should be made for observing the Transit of 1874, to take carefully into account the relations which will be presented during the Transit of 1882. To neglect this precaution would, in my judgment, be as serious a mistake as for one nation to arrange its plans for either transit without a careful reference to the arrangements of other nations. It has been with the object of supplying this want that I have constructed the accompanying chart of the Transit of 1882 ; for although the circumstances of the later transit have been to some degree considered (by myself amongst other students of the subject), I do not think they have as yet been sufficiently brought into comparison with those of 1874. A comparison has indeed been instituted between the two

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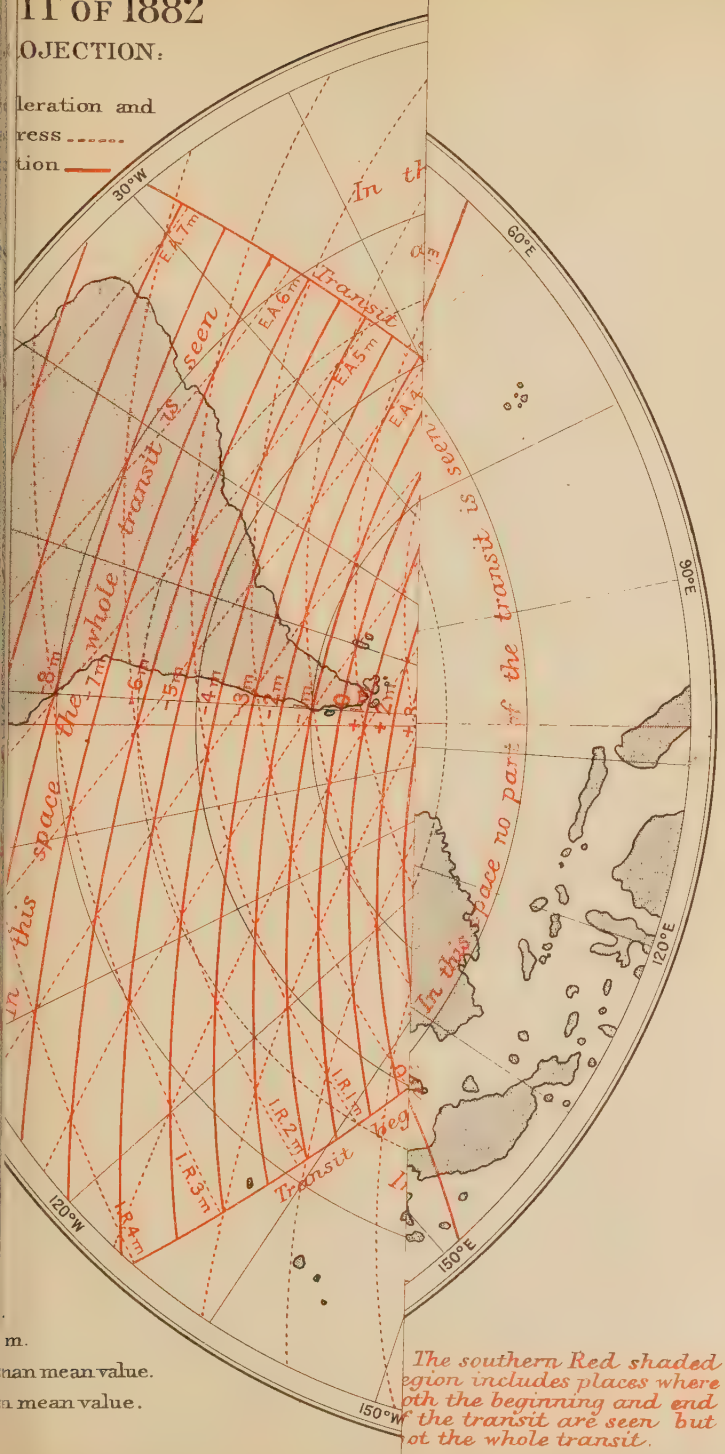

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Malby & Sons, lith.

transits in the *Monthly Notices* for December, 1868, wherein it is remarked that Halley's method "fails totally for the transit of 1874, and is embarrassed in 1882 with the difficulty of finding a proper station on the almost unknown Southern continent." This statement, however, does not by any means accord with the results of my own investigation. On the contrary, I find that Halley's method may be said to fail totally in 1882; while, as is now well known, I find (I may even say I have demonstrated) that Halley's method is the best of all methods depending on *contacts*, for 1874.

So much, with reference to the comparison between the two transits, I maintained in 1870 in Appendix I. to my treatise on the Sun. Mr. Penrose has arrived at a similar conclusion as to the general superiority of 1874 for contact-observations (*Monthly Notices* for April last). Quite recently M. Puiseux has enunciated the same view in a communication to the Paris Academy, which I find thus summarised in *Les Mondes*:—"Le passage de 1874 sera notablement plus avantageux que le suivant pour la détermination de la parallaxe solaire, par les observations de contact, c'est-à-dire par la méthode qui, après tout, donnera probablement les meilleurs résultats. Il est donc à désirer que rien ne soit négligé pour assurer dans les meilleures conditions l'observation du prochain passage..... On pourra, en effet, sans sortir des régions facilement accessibles, obtenir en 1874 des différences de durée de passage s'élévant à 26 minutes, des différences d'heures d'entrée de 21 minutes, et des différences d'heures de sortir de 18 minutes, tandis qu'en 1882 ces différences se réduiront la première à 16 minutes, et les deux autres à 15 minutes."

A brief study of the accompanying map, and a comparison between this map and the corresponding map illustrating the transit of 1874, will suffice not only to confirm these statements (and my own statements to the same effect in 1871), but to show on what circumstances the superiority of 1874 over 1882 for Halley's method depends. I may remark, indeed, that the superiority of 1874 for Delisle's method is more apparent than real, being to a great extent (Mr. Stone thinks wholly) counterbalanced by the slowness with which *Venus* crosses the Sun's limb in 1874.

I would invite special attention to the position of the Halleyan curve marked 0 in the two maps, which curve may be called the Halleyan equator, since it marks the curve on the Earth where the duration has its mean value. It will be seen that this curve lies much farther south for 1882 than for 1874. It leaves a very limited region outside the Antarctic Circle, and if we take lines 10° from the curves marking where transit begins and ends at sunrise and sunset, these lines being taken within the region where the whole transit is seen, it is found that the region of the Earth where the duration will be less than the mean, with a Sun not less than 10° above the horizon both at ingress and egress, is very limited indeed. But in 1874, on the *unfavourable* or northern side of the Halleyan equator, we can find places where an excess

of duration of more than 15 minutes, with the required conditions as to altitude, can be obtained.

If we assume, in fact (which I think will be generally admitted), that no station can be regarded as suitable for Halley's method where the difference between the actual duration and the mean duration is less than half the maximum acceleration or retardation, or where the Sun is less than 10 degrees high at ingress or egress, then absolutely no station whatever is available in 1882, unless the south pole can be approached much nearer even than it was approached by Sir Jas. C. Ross in the famous expedition when Possession Island was discovered.

I confess that the prospect of successful observation at Possession Island, with a Sun only 5° high at ingress, seems to me so slight that I should hear with regret of any attempt to carry out the suggested scheme for wintering at Possession Island in 1882.

Note on the Appearance presented by the Fourth Satellite of Jupiter in Transit in the years 1871–3. By Charles E. Burton, B.A., Exp. Phys. T.C.D.

No. 1. Dec. 30, 1871. IV. when first seen, its distance from the limb of the planet being about one of its own diameters, appeared extremely dark, possibly as dark as when last seen, and approaching mid-transit. I could not satisfy myself that there was any defect of roundness in the dark spot which was once or twice considered to be bordered on its southern side by a bright crescent. The satellite appeared to traverse a bright zone of the planet, and at $12^h \pm$ G.M.T. was in close juxtaposition to the northern boundary of the Antarctic dusky cap. Definition fairly good, a power of 228 being effective at times on a silvered glass Newtonian equatoreal of 7 inches clear aperture.

No. 2. April 8, 1872, $8^h\,45^m$ to $11^h\,5^m$ G.M.T. IV. appeared during the whole time of the observation as a well-defined, almost entirely black spot. When first observed it had accomplished about one-fourth of its transit, and it was watched till three-quarters of its path had been described. During the first half of its observed path it appeared both blacker and also better defined than during the second half, the air being equally good the whole time. The transit took place along (and I believe within) the S. edge of a dark belt.

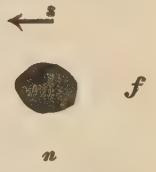
Mr. Erck goes on to say, "My friend Mr. C. Burton drew attention to the fact that the dark spot representing IV. was not round, but decidedly elongated in the direction of the belt during the whole time of observation. In this I concurred."

To this note by Mr. Erck I made one addition; that the following extremity of the elongated dark spot was more acute than the preceding at $11^h\,5^m$ G.M.T. (See *Astronomical Register*,

No. 113, pp. 12–4.) Instrument—the $7\frac{1}{2}$-inch Alvan Clark, O.G. formerly the property of the late Rev. W. R. Dawes, equatoreally mounted and driven by clock. Powers 150 and 400, chiefly the latter.

No. 3. February 4^d 10^h 35^m G.M.T., and for the half-hour following, the shadow of IV. appeared round and black, IV. itself elongated in a direction parallel to that of the belts, and *dark grey*. Instrument, a well-defining achromatic of 3-inch aperture, mounted on table stand and furnished with powers of 112 and 80 diameters. Though the means of observation were in this case so small, yet the presence of the satellite and its shadow on the disk of the planet at the same time gave me great confidence in determining the form of the dark spot on the satellite, which was very distinctly seen.

No. 4. 1873, March 26^d 8^h $5^m \pm$ G.M.T. IV. when first seen had accomplished rather more than two-thirds of its transit and seemed irregular in form, but I should not call it elongated. It was very dark, but several shades lighter than a shadow. The form of the dusky spot at the time given above somewhat resembled that of the spot in the accompanying sketch, a slightly enlarged copy of the same made in my journal at 8^h 55^m to represent the aspect of the satellite at 8^h $15^m \pm$ G.M.T. The arrow indicates approximately the *p.* and *f.* direction. Towards 8^h 50^m I repeatedly had the impression that there was a minute bright speck on or very close to the preceding limb of the satellite, but the state of the air at the time precluded the attainment of certainty on this point. (*c. f.* No. 1, and Mr. Roberts' observations in *Monthly Notices* for May for the current year.) Instrument used, a Newtonian equatoreal of 12-inch aperture, with silvered glass mirrors and R.A. driver; the magnifying powers employed being 230 and 408. This telescope leaves nothing to be desired in the way of defining objects of extreme delicacy under powers up to 940.



The late Mr. Dawes, in summing up the results of his observations of III. and IV. in transit (*Monthly Notices*, xx. 246–7) remarks, "I have noticed the *fourth* satellite to be always much the darkest, and though the dark spot is never quite round, yet that it is more nearly so than the third ever is." He goes on to remark upon the deficiency seen by him at the limb of the satellite when it was shining freely on dark sky, and figured in the illustration accompanying his paper quoted above. If the satellite were to pass on to the disk of *Jupiter* while presenting the aspect last mentioned it would evidently be seen as an imperfect and exceedingly dark ring enclosing a dusky shading of much less intensity. I have not been able to find any account of such an appearance; all the records of transits of this satellite which I have examined

stating that the dark spot seen was, if anything, darkest towards its centre, and estimating its magnitude as somewhat less than that of the satellite when seen on a dark ground.

With the above facts my own observations seen to be in perfect accordance. I trust I shall not be considered presumptuous in having made the above statement, as the telescopes made use of in examining the forms of the disks of the satellites invariably show two of them, namely, the second and third, with truly round sharp outlines, free from the slightest trace of scattered light if the air be favourable, under powers of 500 diameters and upwards.

On a review of the whole of the facts in my possession, I incline to an impression that they may be plausibly explained by two assumptions—(1) That the fourth satellite's periods of orbital and axial rotation are identical; (2) That an extensive dusky shading exists on that hemisphere which is turned towards us at the time of inferior conjunction, variable in area and probably also in intensity.

May 22, 1873.

Note on Jupiter, 1873. By E. B. Knobel, Esq.

No account of the physical aspect of *Jupiter* in 1873 having, as far as I am aware, been presented to the Society, I am induced to submit the accompanying three sketches made under favourable circumstances, and which I think are not without interest.

The most striking feature is the great change in the equatorial zone; the port-hole markings, which were conspicuous at the previous opposition, have disappeared, and long, irregular, broken masses, horizontal and inclined at a considerable angle to the equator, have taken their place. The north temperate dark belt, which has been previously depicted as single, is really a double belt, as in the drawings. On April 20th, and May 11th, the south tropical dark belt * appeared thinned out towards the east. The south temperate dark belt has appeared of irregular width, widening towards the west, as in sketch No. 3.

Atmospheric influences this year have been fatal to observations of colour; but on May 11th, definition being remarkably good, the south tropical dark belt was observed of a brick-red tint, more decidedly red than the darker parts of the equatorial zone.

In sketch No. 1, the fourth satellite is represented in transit. An observation of this transit by Mr. Roberts appears in the *Monthly Notices* for April, and therein particulars of the emersion are requested. Having observed the transit and emersion very closely with my $8\frac{1}{2}$-inch reflector, I can only say, in reply to

* The south tropical dark belt is really part of the equatorial zone, but I have given it a distinctive name in consequence of its thinning out, and therefore appearing like a separate belt altogether.

Mr. Roberts, that I did not notice the appearance in the satellite he describes. It appeared black, but not so decidedly black as a shadow; it performed the transit, half of it seen on a bright mass, half on a dark portion of the equatorial zone, as in sketch No. 1. On emersion, I have noted "the satellite appeared as a disk, the one-half on the planet forming a notch in the limb, the other half clear of the planet, just discernible; when quite clear of the limb, the satellite shone with a faint dusky light." I did not test its visibility with a less aperture.

Burton on Trent, June 9th, 1873.

Note on the Disappearance of the Coloured Equatorial Belt of Jupiter. By John Browning, Esq.

The colour of the equatorial belt of *Jupiter* was fading during the last weeks of the previous opposition; during the present opposition the colour has been scarcely, if at all, perceptible; there is a conspicuous absence of any intense markings on the surface of the planet, the copper-coloured belts being fainter than usual. Great changes have taken place in the fainter markings, and some of these with great rapidity. On several occasions the belts have appeared inclined at a considerable angle to the equator. During the whole of the opposition the definition has been so uniformly bad that I have found it useless to make drawings of the planet.

Note on the Mass of Jupiter. By W. T. Lynn, B.A.

In *Monthly Notices*, vol. xxvii. No. 1, for November, 1866, I had the honour to lay before the Society an account of a determination of the mass of *Jupiter* as deduced by Professor Krüger from the observations of *Themis*, a planet which, from the position which it sometimes occupies with respect to *Jupiter*, offers peculiar advantages for the purpose in question. He has now availed himself of the fresh material afforded by subsequent observations, and also succeeded in removing an uncertainty to which one of his former normal places was exposed; and the result has been communicated to the *Astronomische Nachrichten* (No. 1941). It gives for the mass of *Jupiter*, compared with the Sun $\frac{1}{1047\cdot538}$, and it will be of interest to compare this with other values of the same quantity determined by different methods. Airy's last-determined value from the motions of the satellites was $\frac{1}{1046\cdot77}$; Bessel's in the same manner $\frac{1}{1047\cdot879}$; Captain Jacobs', also from observations of the satellites made by himself at Madras in

1857, $\frac{1}{1047{\cdot}54}$; Professor Möller's, from the motions of Faye's Comet, $\frac{1}{1047{\cdot}788}$. As the difference between the largest and smallest of these values does not exceed the $\frac{1}{1000}$th part of the mean, we may consider this important element in the solar system as well established; and it is very satisfactory to find determinations made by different methods so well confirmatory of each other.

Notes on Mars, 1873. By E. B. Knobel, Esq.

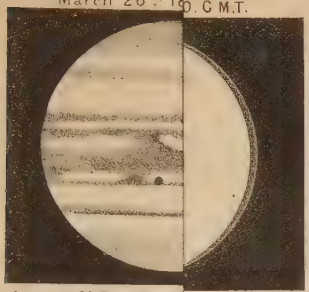
Observations of *Mars* at the opposition of 1873 have been attended with many atmospheric impediments. The planet's low altitude, coupled with unsteady air for many nights, has rendered the accurate delineation of its features most difficult.

The accompanying series of seventeen sketches, which I beg to submit to the Society, has been made with an 8½-inch silvered glass reflector, of excellent quality, mounted as an alt-azimuth, and only those sketches are exhibited in which I have confidence in their representing what was actually observed. No sketch was made without the air was sufficiently steady to bear a power of 250, at least, on the planet.

Many features have been noticed agreeing fairly with the observations of Mr. Dawes, but with some noteworthy exceptions —though I should say that, not having seen Mr. Dawes's drawings, except those given by Mr. Proctor in his *Other Worlds*, and those in the *Astronomical Register* for 1865, I can only judge of the agreement or disagreement by comparison with Mr. Proctor's charts of *Mars* in the *Monthly Notices* for January 1873. And here I must refer to the beautiful accuracy of some of these charts in representing certain aspects of the planet. Sketch No. 14, for instance, might almost have been copied from one of them. The most remarkable exception is shown in sketches Nos. 5 to 13, in which a dark marking is depicted stretching nearly to the north pole, which I cannot reconcile with any drawings I have seen, except one of Secchi's in Chambers' *Descriptive Astronomy*, with which it agrees very well. This dark marking is well and clearly, though by no means sharply, defined on the west, and from it proceed, in a westerly direction, two bands much less dark, as shown in Sketches Nos. 12 and 13. No trace whatever of any light marking across this dark mass was observed on any occasion, though carefully scrutinised under all powers. Glimpses of a band of light S.E. of it were observed on a few nights, as shown in Sketches Nos. 5 to 9.

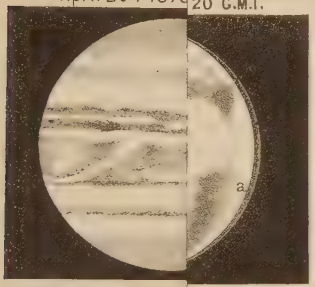
Due east of the centre of this dark marking, a white spot was noticed from May 8th to 22nd. On May 19th, at 10.20, and May 22nd, at 11.30, this white spot was seen on the terminator, glistening as bright as the polar ice; and I would remark, though

Nº1. JUPI
March 26th 18 0. G.M.T.



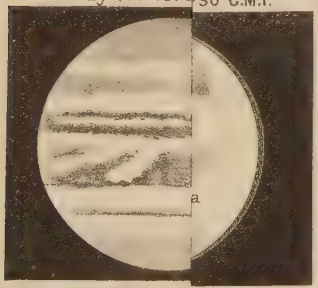
Aperture 8½ Focal length ns, Power used 250
Sat. IV in

Nº2. JUPI
April 20th 1873 20 G.M.T.



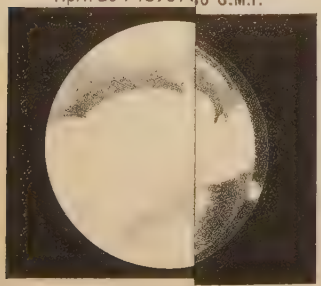
Aperture 8½ ins Focal length ns, Power used 250

Nº3. JUPIT
May 11th 1873 30 G.M.T.



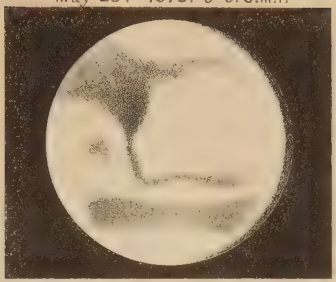
Aperture 8½ ins Focal length s, Power used 250

Nº1. MARS
April 20th 1873. 0 G.M.T.



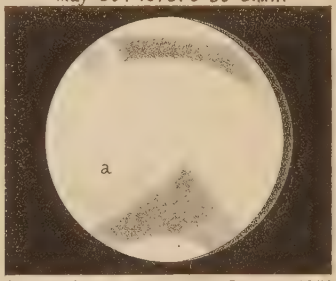
Aperture 8½ ins Focal length (Power used 250.
inator

Nº14. MARS
May 23rd 1873. 9·0. G.M.T.



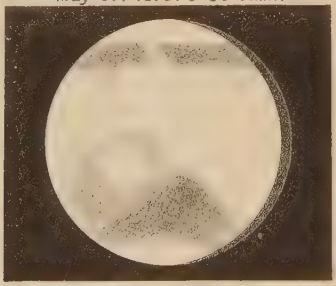
Aperture 8½ ins Focal length 64 ins Power used 306
Kaiser Sea observed in same position April 19th 13·30 G.M.T.

Nº15. MARS
May 30th 1873. 9·50 G.M.T.



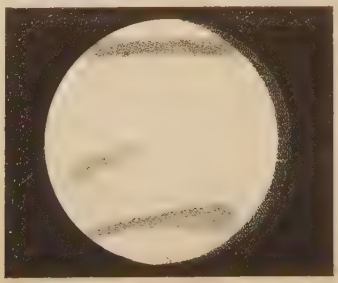
Aperture 8½ ins Focal length 64 ins Power used 250
a. *Same tint as Central Space*

Nº16. MARS
May 31st 1873. 9·30 G.M.T.



Aperture 8½ ins Focal length 64 ins Power used 250

Nº17. MARS
June 8th 1873. 8·30 G.M.T.



Aperture 8½ Focal length 64 ins Power used 250

E.B.Knobel. del

Malby & Sons. lith.

it requires confirmation, that I thought the spot brighter on the terminator than when near the centre of the disc. The sketch made May 22nd, No. 13, represents the white spot apparently raised above the disk by irradiation, though of course exaggerated.

With regard to the region containing "Dawes' Forked Bay," south of this dark marking, I would beg to direct attention to the great distinctness of all this coast-line. It has appeared to me more sharply defined than any other feature in the Martial surface. Momentary views of exquisite definition were obtained on May 19th and 22nd, when more was seen than I could possibly depict in the sketches; several pointed markings were observed with great distinctness, but I could not detect the band connecting this sea with that north of it. This connecting band, called "Dawes' Strait," is a very difficult object, and I could seldom see it. I noted it on May 12th, and also on the following night; but the drawings Nos. 7 and 9, as regards this feature, do not accord very well; in one it is shown as a straight marking, in the other it is curved.

The comparative clearness of the northern Martial sky and obscuration of the southern have been constantly noticed; frequently dark markings have been clearly visible up to the north polar zone, but on no occasion have I detected any markings so near to the south pole.

The north polar ice has occasionally been visible, raised by irradiation, as a projection from the disk. On June 1st, at $9^h\ 30^m$, I noticed particularly that, with a power of 144, the north polar ice appeared projected beyond the disk of the planet, whereas with 300 the very small ice cap seemed to be within the disk, and situated eccentrically in the polar zone.

The south polar ice, it is also believed, has been observed, especially on May 14th, when it appeared of quite a pale sky-blue colour, evidently by contrast.

The difference of tint in the dark markings of the planet *Mars* does not appear to have attracted much attention from astronomical observers, and doubtless in many instances markings have appeared less dark than they have been noticed at other times, in consequence of haziness in the Martial atmosphere. But the result of careful study of the planet, in 1873, seems to prove that there are very great differences in the tint of these markings, and that these differences are constant. The darkest markings I have observed are the "Kaiser Sea," and the dark marking described above, which I presume to be "Delambre Sea." The faintest shades which appeared constant in tint are surrounding the spot called Fontana Land.

A close examination of the Kaiser Sea has revealed a curious absence of uniformity in tint, which doubtless has been remarked by much more experienced observers than myself. I beg to append a diagram in which I have reduced to an outline the particular differences I have observed (of course no outline was

actually seen).* The darkest region appears to be contained within the red line, and in Mr. Dawes' drawing, No. 6, in the *Astronomical Register* for 1865 I can detect the same feature; but within this boundary some intense dark markings were observed, after long and severe scrutiny. These particularly dark marks seemed to have a branching character, and were observed on May 25th and 27th with a high power, and came out very much more distinctly through slight fog or haze, or a light passing cloud which intensified them and first revealed them to me. I look with much interest to the results obtained by other and better observers with more powerful optical means; but I must mention that, when the Kaiser Sea was visible in April, I did not notice anything of these peculiarly intense marks, though the dark region marked in red was very distinctly made out.

Burton-on-Trent, June 11, 1873.

Clock by Dr. Franklin. By R. J. Lecky, Esq.

The clock, which I have much pleasure in showing to the Society this evening, was made about the year 1819 for Roger Dartnell, Esq. M. D., Youghal, Co. Cork, and was used as his sidereal clock, in his Observatory on the town wall of that place, until his death, in 1832, when it came into my possession by bequest from him. The pendulum, with its mode of suspension, the friction crutch, and the weights, I have added to it myself.

It is, I believe, the simplest form of a really useful clock ever contrived, and is described in Rees' *Cyclopædia*, article "Clock," and figured in the plates of *Horology* as invented by Dr. Franklin; but Dr. Rees does not give his authority for this. He also gives another of somewhat similar construction by Ferguson, but not so simple as Franklin's. The train consists of only three wheels and two pinions. The great or centre wheel has 160 teeth, driving a pinion of 10 leaves on the arbor of the intermediate wheel; this has 120 teeth, driving 8 leaves on the 'scape wheel, which is of the ordinary kind, and has a simple "Graham" dead-beat 'scapement, not jewelled. This wheel, of course, carries the seconds-hand in the usual way; and the great wheel, which revolves in four hours, carries a hand which denotes both minutes and hours, the periphery of the dial being divided into 240 minutes, and each of the four quadrants consecutively numbered 0 to 60. Each quadrant, therefore, represents three hours, within which time it is requisite to know the hour; and herein consists the greatest drawback to the usefulness of this form of clock. This, however, might be easily remedied by a 12 or 24-pointed star and divided plate or hand set forward by four pins in the great wheel. The driving-weight simply acts on a grooved pulley fixed to the arbor of the great wheel, as in a common Dutch clock, and has a maintaining spring and ratchet to keep the clock going while being

* This drawing was exhibited at the Meeting.

wound. Mounted in this way it would require to be wound daily; I have, however, added a weight and counterpoise, fitted as double-sheaved blocks, the sheaves being contained in the body of the weights, which enable it to run for eight days; and by making the string endless, and passing it over a winding pulley, it acts as a "Huyghens pulley," thereby rendering the maintaining spring useless. The driving-weight is eight pounds, and the counterpoise four, the effective power, therefore, being 4 lbs.; and as this is divided on to four strings, the actual weight which propels the clock is only 1 lb. minus the friction of the pulleys. This gives the pendulum a swing of 3° 10′, the angle of escape being 1° 24′ (or 42′ at each side of zero); the excess being, therefore, 1° 46′ (or 53′ at each side). This excess is increased 14′ by using a single string with 1 lb. driving-weight, instead of the four sheaved blocks, owing to the decreased friction.

In a series of experiments on the swing, the clock being fresh cleaned and oiled, with weights increasing from $3\frac{1}{2}$ oz. up to 32 oz., I found that at this lower weight the clock would not go, but with $3\frac{3}{4}$ oz. it went, the swing being 1° 32′; with 4 oz. the swing was 1° 38′; 5 oz., 1° 56′; and the average increase of swing being from 5 to 8 oz., 12′; 8 to 12 oz., 9′; 12 to 16 oz., 6′; 16 to 24 oz., $4\frac{1}{2}$′, and 24 to 32 oz., 3′, the full swing being at this latter weight 4° 36′, or 2·18 at each side zero.

The pendulum is an ordinary Graham's quicksilver compensation. The rod is of the finest cast steel, and the bottle a piece of 2-inch cast-iron pipe, bored and turned, the top and bottom being wrought-iron. The rod passes through and is screwed into the latter, with a counter-nut and pointer below. The adjustments for both rate and beat are at the top, and can be used without stopping the clock. The screws for adjusting the beat move a slide which carries the pendulum; and one of them, that on the right-hand side, impinges on a loose brass piece which pinches the pendulum-spring against the edge of the slide, thereby always retaining it at the same point of suspension. The screw for adjusting the rate moves the pendulum-spring between this loose piece and the main slide, the right-hand beat-screw being first loosened; and the spring is suspended to its screw, as well as attached to the top of the pendulum-rod by pins passing through a centre line, thereby avoiding unequal tension to the edges of the spring, which is the constant cause of breakage. There is also a clamping screw to the spring at the top of the pendulum, but this is not tightened until the pendulum has found its true position.

The pendulum contains 11 lbs. 10 oz. mercury, 7·8 inches deep, the weight being altogether 17 lbs. 14 oz. I believe it to be slightly under-compensated.

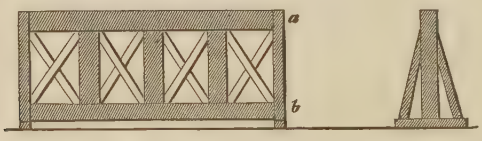
I added an anti-friction crutch to the pallets, which I believe to be an essential benefit, although seldom adopted. It allows for the friction arising from the point of suspension of the pendulum and the centre of motion of the pallets not being in the same right line.

The case in which this clock is mounted is composed of slate slabs, the back being a single slab $1\frac{1}{4}$ inches thick, and to this the pendulum is suspended independent of the rest of the clock. The weight and rigidity of the slate give it great stability, and the clock goes with great steadiness, is very readily adjusted; and if a minimum of friction be a desideratum, I think this mode of construction possesses it more than any other.

On Sympathetic Influence between Clocks. By William Ellis, Esq. of the Royal Observatory, Greenwich.

It has been stated by clockmakers that clocks, if placed near together on the same wall or other support, will mutually influence each other, and in vol. xli. of the *Philosophical Transactions* there are two papers by Ellicott, giving an account of the "influence which two pendulum clocks were observed to have upon each other." Lately, however, having to test a number of clocks at the Royal Observatory, provided for use in the observations to be made of the Transit of *Venus* in the year 1874, some curious instances of sympathetic influence came accidentally under my own notice, concerning which the Astronomer Royal has requested me to draw up for presentation to the Royal Astronomical Society, a statement of the facts observed, since they appear to possess sufficient interest to make their publication desirable.

In order conveniently to rate at the Royal Observatory the clocks alluded to, a large and stout wooden stand was constructed, about eleven feet long and five feet high, along both sides of which the clocks could be ranged side by side. The stand is of the annexed form. The cross bracing (distinguished in the side



Side view. End view of one of the end standards.

view by not being shaded) was not at first supplied, and it was without these bracings that the stand was first used. Each clock-case was firmly screwed both to the upper and lower horizontal bars of the stand (*a* and *b* of the side-view sketch). When rating was commenced, two clocks only had been fixed, "Graham, No. 2," and "Arnold, No. 2," and it was soon remarked that there existed sympathetic influence, the difference between the times indicated by the two clocks remaining day after day constant. They were rated from 1872, May 2 to May 21, and an abstract of the rating is given in the following table :—

1872.	Graham 2 fast of Sidereal Time.	Arnold 2 fast of Sidereal Time.	Graham 2 fast of Arnold 2.
	m s	m s	s
May 2	3 44·6	3 41·5	3·1
11	3 52·2	3 49·1	3·1
18	3 40·9	3 36·9	4·0
20	3 40·9	3 37·6	3·3
21	3 41·5	3 38·3	3·2
1	2	3	4

The numbers in column 4 show that the difference between the clocks was the same ($3^s{\cdot}1$) on May 11 as on May 2, comparisons on intermediate days, not inserted in the table, showing that this difference remained during the nine days constant. The clocks both gained in the same period $7^s{\cdot}6$, or $0^s{\cdot}84$ daily, and as the pendulum of one clock swung to the left, that of the other went to the right.

Now on May 11 the clock Graham 2 was stopped, The rate of Arnold 2 immediately changed considerably. Between May 11 and May 18 it lost $12^s{\cdot}2$, or $1^s{\cdot}74$ daily, or its daily rate changed, on the stoppage of Graham 2, from $0^s{\cdot}84$ gaining to $1^s{\cdot}74$ losing, that is, it *increased its losing rate by* $2^s{\cdot}58$.

On May 18 the clock Graham 2 was again set going, but with its pendulum swinging now in the *same* direction as that of Arnold 2. That this was done is seen by the difference (in column 4 of the table) which was left $4^s{\cdot}0$ instead of $3^s{\cdot}1$. But on May 20 this difference of $4^s{\cdot}0$ had become lessened to $3^s{\cdot}3$, and on May 21 to $3^s{\cdot}2$, showing approach of the pendulums to their former relative positions. The *rate* of Arnold 2 correspondingly returned to its former value: between May 18 and 20 it was $0^s{\cdot}35$ gaining, but between May 20 and 21 it had become $0^s{\cdot}7$ gaining. Or, the starting of the clock Graham 2 changed the daily rate of Arnold 2 from $1^s{\cdot}74$ losing to $0^s{\cdot}7$ gaining, that is, it *decreased its losing rate by* $2^s{\cdot}44$. Thus a change of rate was produced in the clock Arnold 2 by the starting of Graham 2, in the opposite direction, and of nearly precisely the same amount as that produced by the stoppage of Graham 2. (Neither of the two clocks, on the starting of Graham 2 on May 18, took up its former rate at once, because of the disturbing effect introduced by setting the pendulum of Graham 2 into an opposite position relatively to that of Arnold 2, as mentioned. But between May 20 and 21 the clocks had about returned to their former state; the difference having become $3^s{\cdot}2$ as compared with $3^s{\cdot}1$, and the rate, 0^s 6 gaining for Graham 2, and $0^s{\cdot}7$ gaining for Arnold 2, as compared with $0^s{\cdot}84$ gaining. The rating was discontinued on May 21.)

The wooden frame was now strengthened by the addition of the cross bracing before spoken of. On further trial of the clocks, no further disturbing effects (as indicated by the clock rates) were perceived. Many other clocks were afterwards fixed to the stand,

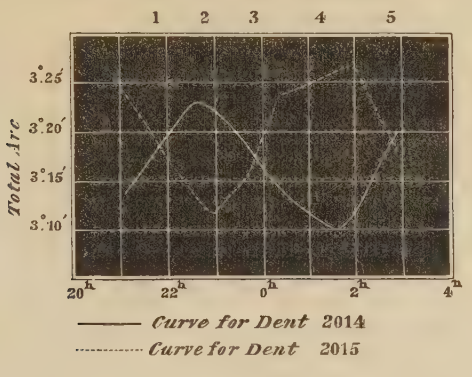
and these, with others mounted each on a separate stand, were simultaneously rated. Judging by their rates, all these clocks performed satisfactorily. But in the course of time it became evident that, whilst the arcs of vibration of the pendulums of *all* the clocks on separate stands were very uniform, those of *all* the clocks on the great stand (at this time nine in number) showed great variations, indicating that sympathetic influence still appeared to exist, although the effect was not now perceptible in the rates. To investigate this, all the clocks on the great stand were for a week stopped, excepting one, and during this week its pendulum maintained a nearly constant arc. The same thing was done as regards another of the clocks, with a like result. The clocks were then all set going again, and observations of the arcs of three of them made at frequent intervals: one of the clocks selected having an extreme losing rate, one an extreme gaining rate, and the other a rate intermediate between those of the other two. The observations are contained in the following table:—

1873.	Dent 2014 Daily Rate 8ˢ·3 losing.	Dent 2011 Daily Rate 4ˢ·1 losing.	Dent 2015 Daily Rate 1ˢ·5 gaining.
	Total arc of vibration.		
d h m	° ′	° ′	° ′
Feb. 27 21 45	2 57	3 53	3 19
22 45	3 7	3 47	3 9
23 0	3 9	3 45	3 9
23 15	3 12	3 42	3 10
23 30	3 15	3 41	3 11
23 45	3 14	3 35	3 15
28 0 45	3 8	3 21	3 29
1 15	3 5	3 15	3 31
1 45	3 1	3 10	3 29

These numbers show that the arcs of vibration were in a state of rapid change, in nature periodical, but that the effect produced by the disturbing action was different in each clock. To study the action more simply, all the clocks were now stopped excepting two, Dent 2014 and 2015, and the following observations made:—

1873.	Dent 2014 Daily Rate 8ˢ·1 losing.	Dent 2015 Daily Rate 1ˢ·4 gaining.
	Total arc of vibration.	
d h m	° ′	° ′
March 4 21 10	3 14	3 24
22 30	3 23	3 14
22 50	3 23	3 12
23 40	3 19	3 16
5 0 25	3 14	3 24
1 35	3 10	3 26
2 0	3 12	3 27
2 50	3 20	3 18

The relative change of arc is better seen in the following diagram:—



At the point 2 the two pendulums were swinging simultaneously in opposite directions, and at the point 4 in the same direction, or at the point 4 the pendulum of the clock 2015 had advanced $1^{s}\cdot0$ on that of 2014. Consequently between the points 1 and 5 the pendulum of 2015 had advanced $2^{s}\cdot0$ on that of 2014; the interval occupied in making this advance being, according to the time scale of the diagram, from about $21^{h}\ 50^{m}$ to $2^{h}\ 45^{m}$, or about $4^{h}\ 55^{m}$.* Now, by the observed rates, given in the last preceding table, it will be seen that the clock 2015 was gaining $9^{s}\cdot5$ daily on 2014; it should, therefore, advance $2^{s}\cdot0$ on 2014, in $24^{h} \times \frac{2}{9\cdot5}$, or $5^{h}\ 3^{m}$, which result differs by a few minutes only from that found from the diagram. In this mutual action of two pendulums there is another circumstance to be remarked, which is that, in the alternate variations of arc, as one pendulum attained its *greatest* arc, the other reached its *least* arc.

This simple experiment with two clocks shows clearly the dependence, in a case of mutual disturbance, of the variations of arc on the difference of rate, the period in which in each clock the arc goes once through all its changes corresponding to the advance of one pendulum on the other by one complete vibration (or 2^{s}).

It appears, therefore, that the pendulums of two clocks, fixed to the same support, tend to influence each other, in degree, according to the facility with which the support can be put into or communicate vibration, and further, that

* A little inequality is introduced into the diagram from the fact of the mean value of arc for Dent 2015 being a little greater than that for 2014. In strictness the dotted curve should be lowered by about 4′, which would shift the points of intersection 1 and 5 a little to the left, and the point 3 a little to the right, thereby rendering the spaces between the several points equal, without affecting the absolute distance between the points 1 and 5.

(1) The influence may be imperceptible to ordinary methods of observation ;
(2) Or may be perceptible only as affecting the arcs of vibration in a lesser or greater degree ;
(3) Or may be sufficiently powerful to cause the clocks to move entirely in sympathy.

In the practical use of clocks, cases (1) and (3) will never cause error ; in the one instance no injurious effect would be produced, and in the other the effect would soon be perceived. But not so with case (2). For the variations of arc would usually cause small alternate accelerations and retardations in the time, which, in the daily rating of an ordinary clock, might not be distinguished or separated from other greater sources of error (as was the case with the Transit of *Venus* clocks, after bracing the wooden stand, on which they were temporarily placed for trial, as before mentioned). No doubt, however, if a clock, supposed to be so influenced, were compared very frequently, by some accurate method, with another independent clock (suppose by coincidence of beats, using an intermediate chronometer), the inequality of rate would then be perceived. Such inequalities, even if small in magnitude, being of periodical character, might affect injuriously any delicate experiment, and would be especially mischievous in any clock used for very accurate or fundamental work. Examination of the arc would, however, always reveal the existence of disturbance.

Some apology may be necessary for the length of this paper, but I have thought that, in a matter of experiment of this kind, it was desirable to give an account of the phenomena observed in some detail.

Royal Observatory, Greenwich,
1873, *June* 10.

On a Recording Micrometer. By W. H. M. Christie, Esq.

In observations of zenith distance with a meridian instrument it is of great importance to secure several bisections of a star during its passage across the field, and also to have a permanent record of the corresponding micrometer-readings for correction of the mistakes which no doubt often occur. To secure both of these objects without throwing any more work on the micrometer-screw, or in any way interfering with its action, there seems to me nothing so simple as putting a thin cylinder covered with paper on the micrometer head and making punctures on it ; but some plan must be adopted for distinguishing the punctures corresponding to the several bisections of the same object, and also those corresponding to any particular object from others previously made. I would suggest two arrangements for this, the latter of which is more complete, but at the same time probably rather too complicated for general use.

TO ILLUSTRATE Mr. CHRISTIE'S PAPER ON
"A RECORDING MICROMETER".

Fig. 1.

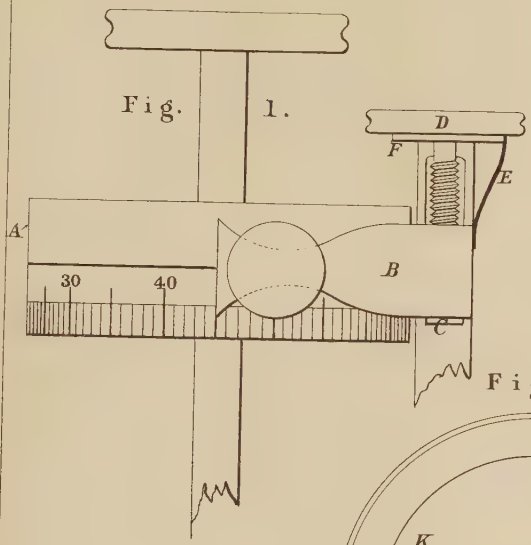


Fig. 3.

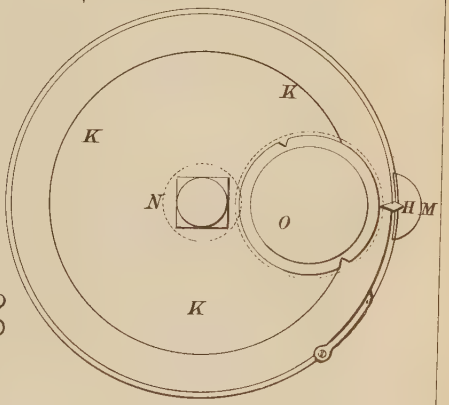
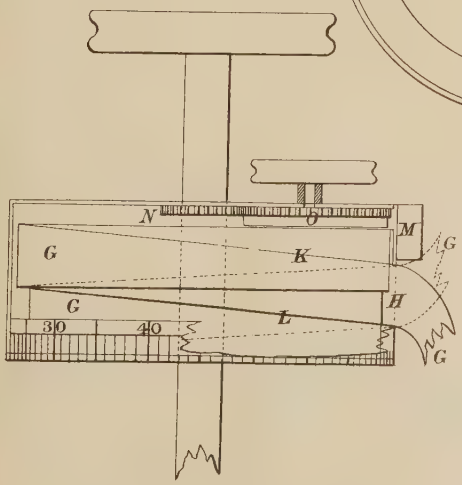


Fig. 2.



Malby & Sons, Lith.

Figure 1 is a front view of the simpler plan. A light brass drum, A, covered with cloth, with a fillet of paper fastened round it, is slipped on to the end of the micrometer-screw and held in its place by a catch; two steady pins on the upper surface of the divided head, and at different distances from the centre, will prevent any shift relatively to the head, and ensure the correspondence of the overlapping part of the paper on the drum with the micrometer zero. A puncture is made by pressing a pricker on the spring, B, against the paper after each bisection of a star, whilst a stop prevents any injurious pressure from being applied to the micrometer. To distinguish the several bisections, the spring is fixed in a slide, C, and carried through a definite space before each bisection by turning the screw, D, through a quarter turn; E is a spring pressing against F, and falling into a notch at each quarter turn of the screw D.

When a fresh drum is put on, the zero must be marked by a puncture which ought to be through the overlapping part of the paper, so as to give both 0 and 100 of the scale. After making several bisections of a star, the punctures are to be read off by bringing them up to the straight edge of the spring and reading off the divided head, each being then marked with a pencil to distinguish it from those made in the next observation.

By using a continuous fillet of paper, this reading off for identification may be dispensed with, fresh paper being used for each new object.

Figures 2 and 3 are a vertical section, and a plan of this second arrangement.

The fillet G passes completely round the micrometer-head, both ends being led through a slit, H, and then coiled up inside the head; the part of the fillet outside may be changed by the following arrangement: — Within the head are two barrels, K, L (one above the other), containing watch-springs, winding in opposite directions; the fillet is wound round the upper barrel, K, many times by the action of its spring, being passed through the slit, H, and after going round the outside of the micrometer-head, is brought inside again through the same slit, and attached to the other barrel, L, when it has been wound up; the fillet is thus stretched by the two springs, and held in position between the jaws of the slit (pressed together by a spring, M), which also mark the zero of the micrometer by prickers making punctures through both parts of the fillet.

The method of recording is exactly the same as in the first plan, all the bisections of any one object being recorded on the same paper.

To change the paper, a toothed wheel, N, on the same arbor as the upper barrel, is turned through rather more than one revolution, by giving half a turn to another wheel, O, which at the same time releases the paper from the jaws of the slit by a cam driving a wedge between them; the lower barrel can thus wind up on

itself, by the action of its spring, all the paper previously outside the head.

If the weight of this arrangement should prove too much for the micrometer-spring, which ought not to be the case, the recording part may be placed on a separate axle parallel to the micrometer screw, which may be made to turn it by means of toothed wheels.

From the pressure of other matters, much delay has occurred in the introduction of these plans, but Mr. Simms has now applied the arrangement first described to the Greenwich Transit Circle, where it is found to answer very well, and the other will probably be made in a short time.

Blackheath, 1873, *June* 12.

Observations of Occultations of Stars by the Moon, 1872 *and* 1873 (*with the deduced Equations between the Errors of the Lunar Elements*); *and of Phenomena of Jupiter's Satellites, in* 1871 *and* 1873: *made at the Radcliffe Observatory, Oxford.*

(*Communicated by the Radcliffe Observer.*)

Occultations.

No.	Day of Observation.	Phenomenon.	Moon's Limb.	Oxford Mean Solar Time. h m s	Observer.
	1872.				
1	Aug. 12	Dis. of λ Libræ	Dark	9 39 37·7	M
2	Sept. 15	,, τ^1 Aquarii	,,	11 22 44·0	K
3	,,	,, τ^2 Aquarii	,,	12 39 42·4	L
4	,,	Reap. of τ^2 Aquarii	Bright	13 43 27·2	L
5	,, 24	Dis. of ε Geminorum	,,	12 22 36·4	K
6	Oct. 11	,, 35 Capricorni	Dark	10 16 48·9	M
7	,, 14	Reap. of 33 Piscium	Bright	6 48 17·3	K
8	Dec. 9	Dis. of *f* Piscium	Dark	7 12 41·3	K
9	,,	Reap. of *f* Piscium	Bright	8 2 14·9	K
	1873.				
10	Jan. 22	Dis. of 28 Libræ	,,	18 23 50·8	L
11	Apr. 2	,, 118 Tauri S*	Dark	9 3 17·8	M & K
12	,,	,, ,, N*	,,	9 3 24·8	M & K
13	May 8	,, γ^1 Virginis	,,	13 5 8·5	K
14	,,	,, γ^2 Virginis	,,	13 5 21·0	K
15	,,	Reap. of γ^1 Virginis	Bright	14 5 10·0	K
16	,,	,, γ^2 Virginis	,,	14 5 21·9	K

Notes.

1872. Aug. 12. The disappearance was instantaneous and the observation good.

Sept. 15. τ^1 Aquarii (disap.); good.

1872. Sept. 15. τ^2 Aquarii (disap.); good. At the reappearance the star was very faint, owing either to thin cloud or moisture on the object-glass.

,, 24. Good, though both Moon and star were tremulous.

Oct. 11 & 14. Good.

Dec. 9 *f* Piscium (disap.); clouds.

,, ,, (reap.); good.

1873. Apr. 2 Hazy clouds covered the Moon and stars at the time of occultation, so as to efface the Moon's unilluminated disk, which was visible before. The observations are good (M.)

Disap. of 118 *Tauri*, S✱ and N✱; good. (K.) The mean of the observed seconds 17·5 and 18·0 for S✱, and 24·5 and 25·0 for N✱ has been taken.

May 8. For disap. of γ^1 and γ^2 *Virginis*, Mr. Lucas gave $8^s{\cdot}8$ for the disap. of γ^1, and $21^s{\cdot}7$ for disap. of γ^2. Both stars disappeared instantaneously, and the observations are considered good.

The observations of reap., though considered good, are not so certain as those of disap., being probably a little late.

In the following table of the errors of lunar elements resulting from the occultations the Greenwich notation is used, and the elements of the *Nautical Almanac* uncorrected. All the computations have been made by Mr. Main by the method given in his treatise on *Spherical and Practical Astronomy*.

The observations are referred to by the Nos. of reference given above.

$$1 + 6''{\cdot}41 = +0{\cdot}946 \times e + 0{\cdot}024 \times f - 0{\cdot}946 \times x - 0{\cdot}026 \times y - 0{\cdot}445 \times t + 1{\cdot}590 \times m - 0{\cdot}955 \times n.$$

$$2 + 15{\cdot}83 = +0{\cdot}959 \times e - 0{\cdot}156 \times f - 0{\cdot}959 \times x + 0{\cdot}155 \times y - 0{\cdot}440 \times t + 0{\cdot}735 \times m - 0{\cdot}990 \times n.$$

$$3 + 13{\cdot}41 = +0{\cdot}690 \times e - 0{\cdot}705 \times f - 0{\cdot}690 \times x + 0{\cdot}705 \times y - 0{\cdot}476 \times t + 2{\cdot}952 \times m - 0{\cdot}989 \times n.$$

$$4 - 15{\cdot}24 = -0{\cdot}932 \times e + 0{\cdot}288 \times f + 0{\cdot}932 \times x - 0{\cdot}289 \times y + 0{\cdot}501 \times t - 2{\cdot}310 \times m - 0{\cdot}989 \times n.$$

$$5 - 16{\cdot}01 = +0{\cdot}871 \times e + 0{\cdot}252 \times f - 0{\cdot}871 \times x - 0{\cdot}250 \times y - 0{\cdot}461 \times t - 2{\cdot}506 \times m - 0{\cdot}893 \times n.$$

$$6 + 0{\cdot}82 = +0{\cdot}712 \times e + 0{\cdot}648 \times f - 0{\cdot}712 \times x - 0{\cdot}649 \times y - 0{\cdot}204 \times t - 1{\cdot}152 \times m - 0{\cdot}976 \times n.$$

$$7 - 17{\cdot}10 = -0{\cdot}713 \times e + 0{\cdot}698 \times f + 0{\cdot}713 \times x - 0{\cdot}698 \times y + 0{\cdot}485 \times t - 0{\cdot}756 \times m - 0{\cdot}972 \times n.$$

$$8 + 22{\cdot}62 = +0{\cdot}103 \times e - 0{\cdot}995 \times f - 0{\cdot}103 \times x + 0{\cdot}995 \times y - 0{\cdot}282 \times t + 2{\cdot}539 \times m - 0{\cdot}945 \times n.$$

$$9 - 11\cdot81 = -0\cdot979 \times e - 0\cdot193 \times f + 0\cdot979 \times x + 0\cdot192 \times y + 0\cdot291 \times t + 0\cdot441 \times m - 0\cdot944 \times n.$$

$$10 + 4\cdot88 = +0\cdot932 \times e - 0\cdot231 \times f - 0\cdot932 \times x + 0\cdot229 \times y - 0\cdot306 \times t + 0\cdot385 \times m - 0\cdot939 \times n.$$

$$11 + 1\cdot64 = +0\cdot836 \times e - 0\cdot374 \times f - 0\cdot836 \times x + 0\cdot376 \times y - 0\cdot437 \times t + 2\cdot549 \times m - 0\cdot920 \times n.$$

$$12 \quad 0\cdot00 = +0\cdot835 \times e - 0\cdot379 \times f - 0\cdot835 \times x + 0\cdot380 \times y - 0\cdot436 \times t + 2\cdot555 \times m - 0\cdot920 \times n.$$

$$13 + 4\cdot60 = +0\cdot546 \times e + 0\cdot838 \times f - 0\cdot546 \times x - 0\cdot838 \times y - 0\cdot394 \times t - 1\cdot268 \times m - 0\cdot902 \times n.$$

$$14 + 4\cdot70 = +0\cdot542 \times e + 0\cdot838 \times f - 0\cdot542 \times x - 0\cdot838 \times y - 0\cdot392 \times t - 1\cdot275 \times m - 0\cdot902 \times n.$$

$$15 - 1\cdot83 = -0\cdot997 \times e - 0\cdot084 \times f + 0\cdot997 \times x + 0\cdot084 \times y + 0\cdot420 \times t - 1\cdot695 \times m - 0\cdot902 \times n.$$

$$16 - 4\cdot34 = -0\cdot997 \times e - 0\cdot084 \times f + 0\cdot997 \times x + 0\cdot084 \times y + 0\cdot420 \times t - 1\cdot695 \times m - 0\cdot902 \times n.$$

Phenomena of Jupiter's Satellites.

Day of Obs. 1871.	Satellite.	Phenomena.	Instrument and Power used.	Oxford Mean Solar Time of Observation. h m s	Greenwich Mean Solar Time from N. A. h m s	Observer.
Feb. 13	III.	Occ. dis. first contact	10-ft. tel. with power 80	8 4 44·3		
		,, bisection		8 7 43·8	8 20	K
		,, last contact		8 10 28·3		
	III.	Occ. reap. bisection	,,	10 48 17·2		
		,, last contact		10 51 46·6	11 0	,,
17	II.	Occ. dis. last contact	,,	7 6 44·1	7 11	L
	I.	Tr. ingr. first contact	,,	11 28 33·0		
		,, last contact		11 34 50·9	11 34	,,
	II.	Ecl. reappearance	,,	12 10 12·2	12 16 37·3	,,
18	I.	Occ. dis. first contact	,,	8 35 2·9		
		,, bisection		8 38 2·4	8 45	K
		,, last contact		8 40 2·1		
	I.	Ecl. reappearance	,,	12 8 59·9	12 14 1·3	,,
20	I.	Ecl. reappearance	,,	6 37 30·1	6 43 1·3	,,
	III.	Oc. dis. first contact	,,	11 57 7·7		
		,, bisection		12 0 22·2	12 8	,,
		,, last contact		12 3 6·8		
Mar. 6	I.	Ecl. reappearance	,,	10 29 17·3	10 34 41·0	,,
22	I.	Ecl. reappearance	,,	8 49 48·3	8 55 14·3	,,

Day of Obs. 1871.	Satellite.	Phenomena.	Instrument and Power used.	Oxford Mean Solar Time of Observation. h m s	Greenwich Mean Solar Time from N. A. h m s	Observer.
Apr. 6	I.	Tr. egr. first app.	Heliom. with power 200	8 43 54·1	8 50	M
		,, bisection		8 45 53·8		
		,, last contact		8 47 8·6		
	II.	Tr. egr. first app.	,,	9 24 17·5	9 34	,,
		,, last contact		9 27 2·1		
1872. Dec. 11	I.	Occ. reap. first app.	Heliom. with power 150	11 39 29·3	11 44	K
		,, bisection		11 42 28·8		
		,, last contact		11 46 28·1		
1873. Jan. 2	I.	Tr. ingr. first contact	10-ft. tel. with power 80	11 53 10·8	12 1	,,
		,, last contact		11 59 39·7		
10	II.	Ecl. disappearance	Heliom.	10 14 57·1	10 20 3·1	L
	IV.	Ecl. reap. first seen	with power 150	10 48 56·8	10 54 29·2	,,
		,, full brightness		10 52 32·2		
25	I.	Tr. ingr. first contact	,,	11 36 52·6	11 45	K
		,, bisection		11 40 17·1		
		,, last contact		11 43 21·6		
27	I.	Tr. egr. first app.	,,	8 22 15·8	8 31	,,
		,, bisection		8 25 15·3		
		,, last contact		8 28 44·7		
Feb. 27	II.	Tr. ingr. first contact	,,	8 50 51·5	8 57	,,
		,, bisection		8 53 36·1		
		,, last contact		8 56 35·6		
	II.	Tr. egr. first app.	,,	11 40 23·4	11 49	,,
		,, bisection		11 43 8·0		
		,, last contact		11 46 7·5		
Mar. 5	I.	Tr. egr. first app.	,,	11 28 42·8	11 38	,,
		,, bisection		11 31 7·4		
		,, last contact		11 33 56·9		
8	II.	Ecl. reap. first seen	10-ft. tel. with power 80	9 58 6·1	10 2 53·8	,,
		,, full brightness		10 0 21·2		
13	I.	Occ. dis. first contact	Heliom. with power 150	8 5 9·0	8 11	,,
		,, bisection		8 6 53·7		
		,, last contact		8 8 53·4		
	I.	Ecl. reap. first seen	,,	11 1 15·3	11 6 16·5	,,
		,, full brightness		11 4 9·8		
22	I.	Ecl. reap. first seen	10-ft. tel. with power 80	7 24 16·3	7 29 22·0	,,
		,, full brightness		7 26 26·5		
	II.	Occ. dis. first contact	,,	10 37 25·6	10 47	,,
		,, bisection		10 40 25·1		
		,, last contact		10 43 24·6		

Day of Obs. 1871.	Satellite.	Phenomena.	Instrument and Power used.	Oxford Mean Solar Time of Observation. h m s	Greenwich Mean Solar Time from N. A. h m s	Observer.
Mar. 24	II.	Tr. egr. first app.	10-ft. tel. with power 80	7 41 9·8	7 48	K
		„ bisection		7 43 34·4		
		„ last contact		7 46 38·9		
26	IV.	Tr. egr. first app.	„	9 56 33·1	10 7	„
		„ bisection		10 1 2·4		
		„ last contact		10 6 1·6		
27	I.	Occ. dis. first contact	„	11 36 24·3	11 44	„
		„ bisection		11 38 53·9		
		„ last contact		11 41 13·5		
28	III.	Occ. dis. first contact	„	7 37 21·5	7 46	L
		„ last contact		7 44 31·3		
	I.	Tr. ingr. first contact	„	8 58 7·7	9 3	„
		„ last contact		9 1 27·2		
	I.	Sh. tr. ingr. first app.	„	9 56 0·7	9 58	„
		„ last contact		9 57 0·5		
	I.	Tr. egr. first app.	„	11 14 50·7	11 23	„
		„ last contact		11 20 59·7		
	III.	Occ. reap. first app.	„	11 18 50·1	11 28	„
		„ last contact		11 25 38·9		
	III.	Ecl. dis. commencement	„	11 27 38·6	11 32 1·6	„
		„ total dis.		11 27 58·6		
	I.	Sh. tr. egr. first contact	„	12 4 17·6	12 18	„
		„ last contact		12 5 27·4		
29	I.	Ecl. reap. first seen	„	9 18 44·0	9 23 58·2	K
		„ full brightness		9 21 16·6		
	II.	Occ. dis. first contact	„	13 0 26·2	13 9	„
		„ bisection		13 2 40·9		
		„ last contact		13 4 55·5		
31	II.	Tr. egr. first app.	„	10 3 10·3	10 9	„
		„ bisection		10 4 55·0		
		„ last contact		10 7 54·5		
Apr. 5	I.	Ecl. reap. first seen	„	11 14 33·0	11 18 41·1	L
7	II.	Tr. ingr. first contact	Heliom^{r} with power 200	9 35 55·8	9 40	K
		„ bisection		9 38 10·4		
		„ last contact		9 40 25·0		
	II.	Tr. ingr. first contact	10-ft. tel. with power 80	9 35 38·1	9 40	L
		„ bisection		9 38 7·7		
		„ last contact		9 41 7·2		
8	III.	Sh. egr. first contact	„	8 44 23·6	9 2	„
		„ last contact		8 48 57·8		
9	II.	Ecl. reap. first seen	Heliom^{r} with power 200	9 41 7·3	9 47 20·8	M
		„ full brightness		9 43 30·9		

Day of Obs. 1871.	Satellite.	Phenomena.	Instrument and Power used.	Oxford Mean Solar Time of Observation. h m s	Greenwich Mean Solar Time from N. A. h m s	Observer.
Apr. 7	II.	Ecl. reap. first seen	10-ft. tel. with power 80	9 42 2·5	9 47 20·8	K
		,, full brightness		9 45 6·5		
19	I.	Occ. dis. first contact	,,	11 32 58·9	11 40	,,
		,, bisection		11 34 58·6		
		,, last contact		11 36 58·3		
20	I.	Tr. ing. first contact	Heliom^{r} with power 200	8 53 20·5	9 0	M
		,, bisection		8 54 45·3		
		,, last contact		8 58 20·2		
	I.	,, first contact	10-ft. tel. with power 80	8 53 31·8	9 0	K
		,, bisection		8 56 31·3		
		,, last contact		8 59 0·9		
	I.	Tr. egr. first app.	Heliom^{r} with power 200	11 13 22·5	11 20	M
		,, bisection		11 15 32·2		
		,, last contact		11 17 51·8		
	IV.	Occ. reap. first app.	,,	11 33 19·2	11 40	,,
		,, last contact		11 39 48·2		
21	I.	Ecl. reap. first seen	,,	9 31 57·7	9 37 4·9	,,
		,, full brightness		9 33 22·5		
	II.	,, first seen	10-ft. tel. with power 80	9 31 52·7	9 37 4·9	K
		,, full brightness		9 34 2·4		
23	II.	Occ. dis. first contact	Heliom^{r} with power 200	9 35 3·7	9 43	M
		,, last contact		9 39 18·0		
	II.	,, first contact	10-ft. tel. with power 80	9 34 46·2	9 43	K
		,, last contact		9 39 45·4		
29	III.	Tr. ing. first contact	,,	12 4 10·1	12 16	L
		,, last contact		12 16 8·1		
May 3	III.	Ecl. reap. first seen	10-ft. tel. with power 150	10 53 24·0	10 58 18·1	,,
		,, fully seen		10 54 43·8		
		,, full brightness		10 55 53·6		
6	I.	Tr. egr. first contact	,,	9 27 8·9	9 34	,,
		,, last contact		9 30 58·3		
9	II.	Tr. ing. first contact	10-ft. tel. with power 200	8 51 4·4	8 57	,,
		,, bisection		8 54 3·9		
		,, last contact		8 57 58·2		
13	I.	Tr. ing. first contact	,,	9 4 14·1	9 9	,,
		,, bisection		9 5 48·8		
		,, last contact		9 8 18·4		
	I.	Sh. ingr. first contact	,,	10 21 10·4	10 26	L
		,, last contact		10 24 8·8		
24	IV.	Ecl. reap. first seen	Heliom^{r} with power 200	10 43 11·1	10 48 10·4	K
		,, full brightness		10 52 49·5		

Day of Obs. 1871.	Satellite.	Phenomena.	Instrument and Power used.	Oxford Mean Solar Time of Observation. h m s	Greenwich Mean Solar Time from N. A. h m s	Observer.
May 28	I.	Occ. dis. first contact	Heliom^{r} with power 200	10 10 23·9	10 9	K
		„ bisection		10 12 33·5		
		„ last contact		10 15 3·1		
June 6	I.	Ecl. reap. first seen	„	10 0 27·6	10 5 5·5	L

Notes.

1871, Feb. 13. J. III. occ. dis. The time of first contact is considered accurate. Clouds interfered with the other phases. Very cloudy at reappearance.

20. J. III. occ. dis. Very tremulous; cloudy at last contact.

Mar. 22. J. I. ecl. reap. The satellite attained its full brightness, 2½ minutes after first reappearance.

1873, Jan. 25. J. I. trs. ingr. A good observation; the planet and satellites well defined and steady.

April 5. The full brightness could not be satisfactorily estimated, owing to cloud.

Apr. 8. The phenomenon occurred some minutes before the time in the *Nautical Almanac*. The observation of first contact tolerably satisfactory; that of the last contact not so.

9. At the time recorded, only a suspicion of the reappearance, which proved to be correct. (M.)

20. The sky was splendid, but the images were very unsteady. (M.)

23. Cloudy.

29. The sky was splendid; the satellite seemed to disappear and reappear several times before the time noted for the last contact.

May 3. The planet was beautifully defined with the power used (150).

June 6. Too hazy to determine the time of full brightness.

The initials M., L., and K., are those of Mr. Main, Mr. Lucas, and Mr. Keating.

The observations of the satellites for the year 1872 will be found in No. 8 of vol. xxxii. of the *Monthly Notices*.

Proposal to determine the Solar Parallax by Observations of Flora. By Dr. Galle.

(*Translated from a Letter to Mr. Hind, dated Breslau*, 1873, *May* 28.)

Last year I make a proposal to astronomers provided with large telescopes to endeavour to determine the solar parallax by means of the small planets which came nearest to the Earth. I do not know whether you noticed the paper (*Ast. Nach.* vol. lxxx. p. 1) in which this suggestion was made, which consisted in measuring, with a wire-micrometer of an equatoreal differences of declination with Northern and Southern stars situated near the planets at observatories in the Northern and Southern hemispheres; with special reference at that time to last year's opposition of *Phocæa*.

A still more favourable opportunity for such an attempt occurs in the present year in reference to the first of the planets, *Flora*, discovered by yourself, at its opposition in the months of October and November. For the time of opposition coincides accurately with that of perihelion passage, in consequence of which the planet approaches the Earth within the distance of 0·87.

Although a considerable number of astronomers are occupied this year with the preparations for the observations of the transit of *Venus*, and therefore my proposition is not at a very convenient time, yet so many advantages appear to concur at this opposition of *Flora* that I thought it desirable not quite to neglect recommending to observe it, and therefore have already sent, a month ago, a list of comparison stars selected from the Bonn *Durchmusterung* to several observatories in the Southern hemisphere; the Cape of Good Hope (Mr. Stone), Cordoba (Dr. Gould), and Melbourne (Mr. Ellery). I have also sent, some days ago, this list of comparison stars and a paper * on the results of last year's observations of *Phocæa* to Prof. Peters for publication in the *Astronomische Nachrichten.*

You will perhaps excuse the liberty I have taken in making also this special communication to you on this subject, which arises from my desire to learn from you whether there are at present any large telescopes in use in Australia besides that at Melbourne, and whether any support would be given in England, to which country astronomers principally owe the establishment of Southern observatories, to the carrying out of the proposed scheme at one of them; also whether an answer to the proposal could arrive in Europe in time to secure the requisite co-operation. For I do not doubt that *several* observers in the Northern hemisphere would be prepared to participate in it, if they were assured of the co-operation of an observatory in the Southern. Indeed Prof. Brünnow at Dublin, and Prof. Möller at Lund, have in this case already promised their assistance. Moreover, I received some weeks ago a letter from Rear-Admiral Sands at Washington, himself calling attention to the favourable opposition of *Flora*, and, with a view to the co-operation of the equatoreal at Washington, inquiring about a list of comparison stars, which I accordingly forwarded to him also.

Various circumstances have hindered the co-operation of the Southern observatories in the observations of *Phocæa* last year. Meanwhile those made in the Northern hemisphere, as such have come to my knowledge from Dublin, Lund, and Neuchâtel, have still further confirmed me in the opinion of the possibility of obtaining very accurate results by this method. Of the most accurate observations at Dublin and at Lund, only one day indeed (August 18) corresponded; but the declinations of the planet thus obtained, when reduced to the same moment of time, agree within 0″·02, as the result of *one* evening's work, consisting

* These are printed in *Ast. Nach.* No. 1943.

respectively of 24 and 40 comparisons. The comparison of seven days' observations made with a smaller telescope at Neuchâtel with those at Dublin and Lund, gave in the mean an agreement within 0″·04; both as *true* errors with which the planet's parallax would have been affected, had one of the observatories been situated in the Southern hemisphere. Another attempt to determine the value of the solar parallax in this manner would therefore appear to me worthy of recommendation even if the success of the expeditions next year for the observation of the transit of *Venus* should be in all respects satisfactory, which I apprehend can scarcely be assumed to be certain. But so advantageous an approach of one of the small planets as that of *Flora* this year cannot be expected again for several years, especially as it also comes to its perihelion *in the neighbourhood of the equator*, and so in an equally advantageous position for both hemispheres. Some other of the asteroids come indeed a little nearer the Earth, but are either less bright, or pass their perihelia in Southern declinations to which the Bonn *Durchmusterung* does not yet extend. After *Flora*, *Iris* and *Victoria* alone would be the most favourable.

Comparison Stars and Ephemeris of Flora, for the Opposition 1873 October and November.

Mean Berlin Midnight. Flora, 7·9 mag.

1873.	B.D. Pag.	Star's Mag.	For Equinox of 1855·0. R.A.	Decl.	Reduction for Flora (F) to 1873·8. R.A.	Decl.
			h m s	° ′	s	′
Oct. 12		F	2 45 44·3	+3 22·6	+58·6	+4·8
	83	9·3	46 14·3	3 22·3		
	83	8·2	48 40·0	3 26·1		
13	83	9·0	2 44 40·3	+3 16·0		
		F	45 3·3	3 17·5	+58·6	+4·8
	83	8·8	46 34·3	3 21·2		
14	83	8·5	2 43 16·7	+3 12·6		
		F	44 20·7	3 12·5	+58·6	+4·8
	83	9·0	44 40·3	3 16·0		
15	83	8·5	2 43 16·7	+3 12·6		
		F	43 36·3	3 7·5	+58·6	+4·8
	83	9·5	45 21·0	3 4·9		
16	83	9·2	2 40 23·8	+3 8·4		
		F	42 50·3	3 2·8	+58·6	+4·8
	83	9·0	45 2·3	3 0·8		
17		F	2 42 2·8	+2 57·8	+58·6	+4·8
	67	9·2	43 16·7	2 54·5		
	83	9·0	45 2·3	3 0·8		

1873.	B.D. Pag.	Star's Mag.	For Equinox of 1855·0. R.A.	Decl.	Reduction for Flora (F) to 1873·8. R.A.	Decl.
			h m s	° ′	s	″
Oct. 18		F	2 41 13·8	+2 53·0	+58·6	+4·8
	67	9·5	41 32·8	2 50·3		
	67	9·2	43 16·7	2 54·5		
19	67	8·8	2 39 56·8	+2 42·8		
		F	40 23·6	2 48·4	+58·5	+4·8
	67	9·5	41 32·8	2 50·3		
20	67	9·3	2 36 18·1	+2 48·3		
		F	39 32·0	2 43·8	+58·5	+4·8
	67	8·8	39 56·8	2 42·8		
21	67	9·1	2 36 2·2	+2 38·6		
		F	38 39·3	2 39·4	+58·5	+4·8
	67	8·8	39 56·8	2 42·8		
22	67	9·1	2 36 2·2	+2 38·6		
		F	37 45·4	2 35·1	+58·5	+4·8
	67	8·8	40 23·7	2 34·1		
23	67	9·3	2 35 17·3	+2 34·5		
		F	36 50·7	2 30·8	+58·5	+4·9
	67	9·5	39 59·8	2 29·3		
24	67	9·5	2 31 24·8	+2 26·2		
		F	35 55·1	2 26·8	+58·5	+4·9
	67	9·5	39 59·8	2 29·3		
25	67	9·5	2 31 24·8	+2 26·2		
	67	8·3	32 38·3	2 17·9		
		F	34 58·3	2 23·0	+58·4	+4·9
26	67	8·3	2 32 38·3	+2 17·9		
		F	34 1·8	2 19·3	+58·4	+4·9
27	67	8·3	2 32 38·3	+2 17·9		
		F	33 4·4	2 15·8	+58·4	+4·9
	67	7·8	33 15·8	2 15·6		
28	67	9·5	2 31 45·6	+2 8·6		
		F	32 6·6	2 12·5	+58·3	+4·9
	67	7·8	33 15·8	2 15·6		
29		F	2 31 8·4	+2 9·3	+58·3	+4·9
	67	9·5	31 45·6	2 8·6		
	67	9·5	34 54·8	2 10·7		
30	8	F	2 30 10·0	+2 6·3	+58·3	+5·0
	67	9·5	31 45·6	2 8·6		
	67	9·2	32 57·6	2 5·9		
31	67	9·5	2 28 35·6	+2 1·5		
		F	29 11·6	2 3·6	+58·3	+5·0
	67	9·5	31 45·6	2 8·6		
Nov. 1	67	8·3	2 27 21·1	+2 1·5		
		F	28 13·2	2 1·1	+58·3	+5·0

1873.	B.D. Pag.	Star's Mag.	For Equinox of 1855·0. R.A.	Decl.	Reduction for Flora (F) to 1873·8. R.A.	Decl.
			h m s	° ′	s	′
Nov. 1	67	9·5	2 28 35·6	+2 1·5		
2		F	2 27 15·0	+1 58·8	+58·3	+5·0
	67	8·3	27 21·1	2 1·5		
	51	9·3	28 13·3	1 58·1		
3	51	9·5	2 25 48·6	+1 55·0		
		F	26 17·0	1 56·8	+58·3	+5·0
	51	9·3	28 13·3	1 58·1		
4		F	2 25 19·3	+1 54·8	+58·3	+5·1
	51	9·5	25 48·6	1 55·0		
	51	9·3	28 13·3	1 58·1		
5		F	2 24 22·2	+1 53·3	+58·3	+5·1
	51	9·5	25 48·6	1 55·0		
6	51	9·0	2 19 35·9	+1 49·3		
	51	9·3	21 14·6	1 54·7		
		F	23 25·6	1 51·9	+58·3	+5·1
7	51	9·0	2 19 35·9	+1 49·3		
	51	9·3	21 14·6	1 54·7		
		F	22 29·8	1 50·8	+58·2	+5·1
8	51	9·3	2 21 14·6	+1 54·7		
	51	9·5	21 27·6	1 45·6		
		F	21 34·6	1 50·0	+58·2	+5·1
9	51	9·0	2 19 35·9	+1 49·3		
		F	20 40·3	1 49·4	+58·2	+5·1
	51	9·3	21 14·6	1 54·7		
10	51	9·0	2 19 35·3	+1 49·3		
		F	19 47·0	1 49·1	+58·2	+5·1
	51	9·5	21 27·6	1 45·6		
11		F	2 18 54·7	+1 48·9	+58·2	+5·2
	51	9·0	19 35·9	1 49·3		
	51	9·5	21 27·6	1 45·6		
12	51	8·5	2 14 46·6	+1 47·8		
		F	18 3·5	1 49·1	+58·2	+5·2
	51	9·0	19 35·9	1 49·3		
13	51	8·5	2 14 46·6	+1 47·8		
	51	8·8	16 3·6	1 55·3		
		F	17 13·6	1 49·6	+58·2	+5·2
14	51	8·5	2 14 46·6	+1 47·8		
	51	8 8	16 3·6	1 55·3		
		F	16 25·0	1 50·3	+58·2	+5·2
15	51	8·5	2 14 46·6	+1 47·8		
		F	15 37·8	1 51·3	+58·2	+5·2
	51	8·8	16 3·6	1 55·0		
16	51	8·5	2 14 46·6	+1 47·8		

1873.	B.D. Pag.	Star's Mag.	For Equinox of 1855·0. R.A.	Decl.	Reduction for Flora (F) to 1855·8. R.A.	Decl.
			h m s	° ′	s	′
Nov. 16		F	2 14 52·1	+1 52·6	+58·2	+5·2
	51	8·8	16 3·6	1 55·3		
17	51	9·0	2 12 24·1	+1 49·5		
		F	14 8·0	1 54·1	+58·2	+5·2
	51	8·8	16 3·6	1 55·3		
18	51	8·2	2 11 49·8	+1 59·9		
		F	13 25·5	1 55·9	+58·2	+5·2
	51	8·8	16 3·6	1 55·3		
19	51	8·2	2 11 49·8	+1 59·9		
		F	12 44·7	1 58·0	+58·2	+5·2
	51	8·8	16 3·6	1 55·3		

(The planet's place is given for the Equinox of 1855·0, the date of the Bonn *Durchmusterung* (B.D.), and the quantities necessary for reduction to 1873·8 added in last columns.)

Note on Two Telescopic Meteors. By W. H. M. Christie, Esq.

As records of telescopic meteors are rare, it may be interesting to mention that, while observing Tempel's Comet with the Great Equatoreal (12·8 inches aperture) on May 19, I saw two small meteors cross the field. The first, which was seen about $12^h\ 40^m$, G. M. T., was blue and exactly like a star 11 mag. when the telescope is shaken violently. The other crossed the field in a n.f. direction about $13^h\ 40^m$ G. M. T.; it was white, and equal to a star 7 mag., and left a train lasting two or three seconds, and giving a granular light with a very slight tinge of yellow. Power 76.

Blackheath, 1873, *June* 12.

Note by the Secretary:—Since reading Mr. Christie's paper at the last Meeting, Mr. Carrington has drawn my attention to a note by him on the same subject printed in vol. xiv. p. 41, of the *Monthly Notices*. He there mentions that, while employed on an examination of the circumpolar sky, with the object of forming a series of maps to assist him in making a provisional catalogue for his own use, he was struck with the number of meteoric sparks which passed his field of view, often leaving behind little trains of light. These occurred so frequently, that he resolved to note down their paths on his working maps as he proceeded. "In this way," he remarks, "I have collected 49 little paths of very various directions, but among which one may, perhaps, trace the

existence of a little shoal crossing the pole in lines generally parallel to the meridian from 1^h to 13^h R.A. On the second night of the Laurentius stream this year (1853), there was a marked increase in the number seen ; seven were marked down, while others flew through the field too quickly to be caught. As I also perceived increased activity on several cold and windy nights, these minute telescopic meteors appear to consist of two classes, like their larger brethren, those of the naked eye, namely, one of a cosmical and one of an electrical origin."

In addition to Mr. Carrington's observations, telescopic meteors have been occasionally seen by other observers. A few interesting notes on the subject are inserted in the last Annual Report.—E. D.

Elements and Ephemeris of Tempel's Comet of Short Period.

By J. R. Hind, Esq.

Having obtained very satisfactory observations of this comet at Mr. Bishop's Observatory, Twickenham, on May 22, I have used the resulting place, with the positions determined by M. Stéphan at Marseilles on April 3 and May 1, in the calculation of an orbit, taking all the small corrections into account. The elements are as follows:—

Perihelion Passage 1873, May 9·74218 M.T. at Greenwich.

Longitude of Perihelion ..	238° 1′ 6″·0	M. Eq. 1873·0.
Ascending Node	78 43 18·9	
Inclination	9 45 49·1	
Angle of Excentricity ..	27 31 14·6	
Log Semi-axis Major ..	0·5173827	
Mean daily Sidereal Motion ..	594″·19987	

Motion direct.

On comparing with an observation at Marseilles, on May 23, with which I have been favoured by M. Stéphan, the differences between the calculated and observed places were found:—

In R.A. $-5''\cdot8$ In N.P.D. $+8''\cdot2$.

Later observations taken at Mr. Bishop's Observatory are also closely represented.

The following ephemeris applies to the next period of absence of moonlight, when the comet may be still followed with large telescopes:—

At Greenwich, Midnight.

1873.	True R.A. h m s	True N.P.D. ° ′ ″	Log Δ
June 12	16 17 43·6	109 54 36	9·90129
13	17 16·4	110 5 12	
14	16 50·7	110 15 46	9·90538
15	16 26·6	110 26 18	
16	16 4·0	110 36 48	9·90984
17	15 43·0	110 47 16	
18	15 23·7	110 57 40	9·91466
19	15 6·0	111 8 1	
20	14 50·1	111 18 19	9·91982
21	14 36·0	111 28 33	
22	14 23·7	111 38 44	9·92529
23	16 14 13·3	111 48 51	
24	16 14 4·9	111 58 53	9·93106
25	13 58·4	112 8 51	
26	13 53·9	112 18 45	9·93711
27	13 51·5	112 28 34	
28	13 51·1	112 38 19	9·94342
29	13 52·8	112 47 59	
30	13 56·7	112 57 34	9·94996
July 1	14 2·7	113 7 5	
2	14 10·8	113 16 31	9·95671
3	14 21·1	113 25 53	
4	14 33·6	113 35 10	9·96365
5	14 48·3	113 44 22	
6	16 15 5·3	113 53 30	9·97077

When the Moon is again absent in the latter part of July, the comet's track is found to be:—

0^h Greenwich.	R.A. h m s	N.P.D. ° ′	Log Δ′	$\frac{1}{r^2\,\Delta^2}$
July 16	16 19 29	115 15·7	0·00641	0·279
20	16 22 15	115 48·0	0·02203	0·257
24	16 25 32	116 18·5	0·03797	0·236
28	16 29 18	116 47·4	0·05408	0·216
Aug. 1	16 33 32	117 14·8	0·07024	0·198
5	16 38 13	117 40·8	0·08639	0·181

In 1867 Dr. Julius Schmidt observed the comet at Athens till the intensity of light had diminished to 0·2. There is consequently a possibility that it might be seen in July in the present year at one or other of the Observatories of the Southern Hemisphere. The Melbourne reflector in particular might be expected to show it.

Observations of Tempel's Comet of Short Period, made at the Royal Observatory, Greenwich.

(*Communicated by the Astronomer Royal.*)

	Greenwich M.S.T.	Observed R.A.	Observed N.P.D.
	d h m	h m s	° ′ ″
1873, May	19 13 6	16 31 44·5	105 45 7
	22 13 20	16 30 0·3	106 15 40

The correction for parallax is not applied.

These observations, compared with the ephemeris computed by Mr. Hind from Dr. Von Asten's elements (p. 459 of the *Monthly Notices*), give the following corrections to the ephemeris:—

	R.A.	N.P.D.
	s	′ ″
d		
May 19	+28·9	−12 8
22	+28·3	−12 20

Mean Positions of Comparison Stars, for 1873, Jan. 1, from observations made with the transit circle:—

		R.A.	N.P.D.
		h m s	° ′ ″
May 19	*	16 32 35·4	105 44 16·3
22	Oeltzen's Argelander 15776	16 30 19·6	106 35 24·0

The comet was slightly oblong in the direction of parallel, about 40″ in diameter, and had a centrical nucleus, appearing like a blurred star of the twelfth or thirteenth magnitude. It was examined with eye-pieces of various powers, and was distinctly and steadily visible with all.

The observations were made with the Great Equatoreal by Mr. Christie and Mr. H. Carpenter.

Observations of the Planet Venus with a 6-inch Silvered Glass Reflector. By R. Langdon, Esq.

On the 2nd of January, 1873, there was a cloudy mark, of a semicircular shape, extending nearly across the disk, and a dark spot in the centre; the illuminated disk itself was singularly egg-shaped. (See Sketch,* No. 1.) Bad weather prevented me from constantly observing this planet as I should like to have done, but on the 17th April, at 8 o'clock, P.M., I was viewing the

* The drawings here referred to were exhibited at the meeting, and may be seen at the Society's rooms.

planet with one of Mr. Browning's excellent achromatic eyepieces, when I saw two exceedingly bright spots on the crescent —one close to the terminator, towards the eastern horn, and the other in the centre of the crescent. These spots appeared like two drops of dew ; they were glistening in such a manner as to cause the surrounding parts of the bright crescent to appear dull by contrast. (See Sketch, No. 2.) Cloudy weather prevented me seeing the planet again until the 19th, when the spots had disappeared, but the planet on this occasion was seen through the aurora, and the irregular and uneven appearance of the terminator was most beautifully depicted. The whole body of the planet also was distinctly visible. (See Sketch, No. 3.)

Positions of the Radiant Point of the Meteor Shower of Nov. 27th, 1872. By Prof. Herschel, F.R.A.S.

In continuation of the results communicated in a former list,* I have received from many correspondents, and in some cases from original observers of the shower particulars relating to the position of the radiant point of the meteors seen or recorded during the display of the 27th of November last. With the exception of a few additional observations contained in the present list, all the radiant positions contained in this, and in the foregoing list, are represented in the map accompanying the General Reports of the Society on the Progress of Astronomy during the past year † ; and the successive numbers of the following radiant points are continued from those of the previous list in the *Monthly Notices* of December last. The addition of several new radiant-points, chiefly derived from Signor F. Denza's memoir on the shower as seen in Italy, and at many favourably situated places in Europe and America, introduces no very sensible alteration in their general grouping on the map ; but for the more ready comparison of their positions the accompanying diagram exhibits eighty-two places of the radiant point that are sufficiently well described in these observations to be represented in each case by a definite or single point.‡

* These *Notices*, vol. xxxiii. p. 77.

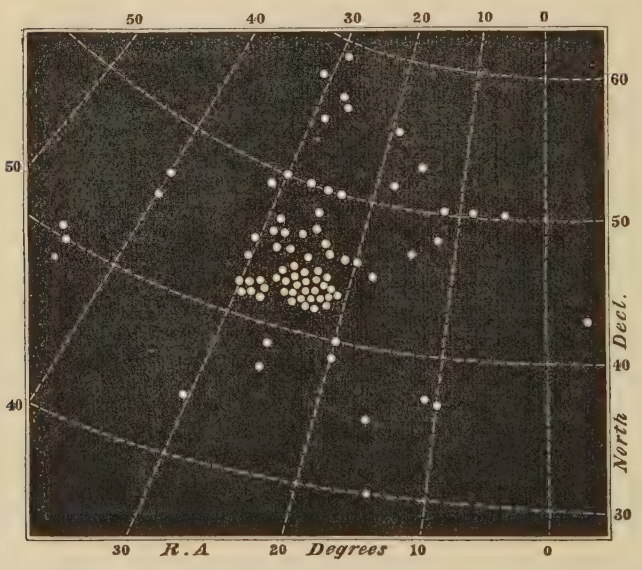
† These *Notices*, vol. xxxiii. p. 255.

‡ Eight new and equally definite positions (marked with duplicate reference numbers in the list) are not contained in this map ; but all the radiant positions marked with an asterisk * (68 observations in this list and 22 in the foregoing one) are included in the following average results. Radiant positions included between brackets, thus [20° + 45°], are approximate positions only, described by the constellations, and they are not inserted in the figure nor included in the mean results. All the radiant places in the former list were well determined points, but certain corrections in them are required which may be thus briefly enumerated,—

No. 1 (at ξ *Cassiopeiæ*) an outlying radiant only ; noted by Mr. Wood, the

The region in which they appear to be most closely concentrated is round a point in about R.A. 24° or 25°, N. Decl. 43°; extending with a slight and perhaps scarcely sensible elongation in R.A. between the meridians of 22° and 28°, and the circles of N. Decl. 42° and 44°. This area, which although not quite extending to it, may yet be regarded as including the many adjacent positions described simply as "*at the star γ Andromedæ*" R.A. 29°, N. Decl. 42°; Nos. 20, 21, 74, 75, 76, 77, 79), contains nearly two-fifths (35) of the whole number (90) of the accurate observations in the list. Another fourth part (22 observations) is contained within the same ten-degree square (extending chiefly north and east of this area) of R.A. and N. Decl.; while the remaining 33 observations are scattered without apparent preference in various

Eighty-two Observed Positions of the Radiant-point of the Meteor Shower of the 27th of November, 1872; showing the principal Radiant region.



directions, and at considerably greater distances round the central region. The average right ascensions and north declinations of

principal radiant point which he determined being included (No. 39) in the present list.

No. 11. The position observed by Prof. Grant alone (see this vol. p. 79) was at R.A. 26°, N. Decl. 44°. A radiant position was also obtained independently by Prof. Forbes which is inserted separately (No. 53) in this list. In Nos. 12, 18, "*φ Andromedæ*" should be *φ Persei*, and "*γ Andromedæ*" ½ (*γ Andromedæ*, *φ Persei*.) The R.A. of *γ Andromedæ* in Nos. 20, 21, should be 29°.

No. 19 is superseded, in the present list by the two more carefully observed positions, Nos. 70, 78, of the Bordeaux observers.

these groups of radiant points, giving equal weights to all the observations are as follows,—

Central region	R.A. 25°·1	N. Decl. 42°·9	(35 obs.)
Adjacent (north-eastern) region	„ 25 ·9	„ 46 ·7	(22 obs.)
Region of scattered radiants ..	„ 23 ·0	„ 45 ·3	(33 obs.)

There does not appear to have been any progressive motion of the radiant-point during the visibility of the shower, the same general distribution of the radiant region round the same centre being, for example, observed in the United States of America as in Europe, although the phase of the shower recorded there occurred five hours later than that generally observed in Europe; and an entire want of agreement in the descriptions of some observers who especially directed their attention towards that point equally removes the suspicion that two definite centres of divergence, like those which the two portions of Biela's comet might produce, or rectilinear, or curvilinear areas of radiation represented the general character of the divergence. But if one half of the seven observations at *γ Andromedæ* are regarded as belonging to the central radiant, and the other half to an apparently thickly strewed region near it, the average centre of the former, or principal radiant, will be at R.A. 24°·7, N. Decl. 43°·3, and that of the less concentrated adjacent radiant points is found to be at R.A. 26°·3, N. Decl. 46°·1, about 3° distant from the former one in a direction about 20° east from north, thus favouring the supposition of a companion radiant point not exactly coinciding in its position with the general direction of elongation of the central group in an east and west direction, nor nearly so distinctly marked, but apparently consisting rather of a considerable diffuseness of the principal radiant region in a particular direction, which was most frequently recorded by the observers on its northern or north-eastern side. On the other hand, the near coincidence of the central group with the average position of the outlying radiant points shows that the general centre of divergence of the least conformable meteors was not sensibly distinguishable from that of the meteoric stream forming the main body of the shower.

Most of the observers of its appearance having been unprepared for the occurrence, and being accordingly unlikely to record their observations with more than ordinary precision, the result of a general comparison of the observations (without assigning particular weights to them) is less likely to err, in this instance greatly, than would be the case with preconcerted observations of an anticipated shower. The mean coordinates of all the 90 definite observations in the list, in right ascension and declination, will thus perhaps present as near an approximation to the real position of the radiant point as a carefully selected

number of all the best observations in this list would certainly be able to afford. The position obtained by thus impartially combining together in a common average all the foregoing observations recorded with sufficient accuracy to be given in the list as single points, is at R.A. 24°·54, N. Decl. 44°·74; and it appears to differ chiefly from the place of the central group, as found above, by the preponderance of several radiant points on the northern side of that group presenting the appearance of greater diffuseness of the radiation there, or of a more scattered radiation on the north than on the south side of the stream, to which the descriptions of several of the observers drew attention in their notes.

It should be noticed that sufficient particulars are in many cases given by the observers to enable a selection to be made of the most accurate observations in the present list; and the average radiant point so obtained would be affected by much smaller mean errors of the observations, and by a less considerable probable error of the result than the position now assigned to it. The mean error of the observations here employed is about 5°·4; while, on account of the great number of the observations, the probable error of the average position, in distance from the true radiant point (if no special bias generally affected the observations*), amounts, almost exactly, to only half a degree.

Should extensions and diffuseness of the radiant region in particular directions, like those now indicated, present themselves in future returns of the shower with sufficient distinctness to be accurately observed, such observations will tend to throw much light on the real nature of the process by which (more rapidly perhaps than ordinarily-constituted meteor-showers, on account of its easily deflected orbit, and of the singular events of its previously-recorded cometary history) the star-shower of Biela's comet is undergoing dissolution of its substance, and is doubtless giving place to a highly complicated meteor-system. A better discrimination of the individual values of the recorded positions of the radiant point will also be an important subject of inquiry, in order to arrive at exact results, which from the novelty of all the circumstances connected with the recent meteoric shower, has not yet been definitely concluded for the many excellent observations here described, but which in a future communication on the fur-

* A few of the observers appear to have regarded the shower as allied or related to that of the August meteors, from the neighbourhood (within about 15°) of its radiant point to that of the "Perseïds," and from its great distance (about 90°) from that of the "Leonids," or meteors of the earlier November star-shower; and to have described its position accordingly as roughly between *Perseus* and *Cassiopeia*, or more simply in *Perseus*. This impression, however, belonged exclusively to a few of the observers who noted the position of the radiant point very roughly by the constellations, and it does not appear to have guided the determinations of any observers towards those constellations who fixed its position approximately or exactly by a well-defined point in the accompanying list of their observations as employed to arrive at the above average result.

ther progress of this investigation it will be attempted to supply more fully, and as far as possible with all the certainty and precision that the observations will permit.

In the general remarks appended to the observations collected in the accompanying table, the references to the original sources from which they have been principally derived are expressed by the following abbreviations. I am indebted to the authors of several valuable memoirs on the appearances of the star-shower in their respective countries for the opportunity to consult many such original descriptions, and to verify the accounts of them which have occasionally appeared elsewhere; and I gladly avail myself of this occasion to record my obligations to Messrs. Denza, Heis, Wolf, Galle, and Prof. Newton, for the invaluable assistance which they have thus afforded me. The following is a list of the abbreviations used to describe their Memoirs and a few other publications mentioned in the references of the table.

D.—Signor F. Denza's Memoir on Observations of the Star Shower in Italy (with particulars of many other foreign observations of the shower.) *Rendiconti del R. Instituto Lombardo*, vol. v. fasc. 20, Dec. 19, 1872 (8vo, 75 pages.)

H.—Prof. E. Heis' *Wochenschrift für Astronomie, Meteorologie, und Geographie*, Nos. 50, 51, 52; Dec. 11, 18, and 25, 1872. Descriptions of the shower received by Prof. Heis from astronomers and observers of shooting-stars in Germany, Denmark, and elsëwhere (8vo, 24 pages.)

M. N., Nos. 2, 3, 6.—These *Notices* for Dec. 13, 1872, Jan. 10, and April 9, 1873, vol. xxxiii. pp. 89–98, 138, and 407.

N.—Observations upon the Meteors of November 24–27th, 1872; compiled by H. A. Newton; including descriptions of the meteors from observers at many stations in the United States of America. *American Journal of Science*, third series, vol. v. pp. 53–62; January, 1873.

S.—*Symons' Monthly Meteorological Magazine*, vol. vii. pp. 187–190, December, 1872.

T.—Descriptions of the Meteor Shower as seen at Palermo, and elsewhere in Sicily, by Prof. A. Tacchini. *Comptes Rendus*, Dec. 23, 1872; vol. lxxv. pp. 1788–1790.

V.—Descriptions of the Star Shower, principally as observed in France; communicated to the French Academy of Sciences, by M. Le Verrier. *Comptes Rendus*, Dec. 2, 1872; vol. lxxv. pp. 1552–1560.

W.—Notices of the Meteors of November 27th, 1872, by observers in Switzerland, compiled by Dr. R. Wolf. *Quarterly Notices of the Zurich Observatory*, December, 1872 (Extract, 4 pages, 8vo.)

List of Radiant Points of the Meteor Shower of November 27th, 1872.

[*Continued from the Monthly Notices for December*, 1872.]

N.B.—Radiants marked thus * (excepting the duplicate Reference Nos. entered in this list after the drawing was complete) are projected on the accompanying Map. References and Remarks on the Observations are contained in brackets, thus [*M. N.*, No. 2].

Ref. No.	Observer.	Place of Observation.	Local Time of Observations From	Local Time of Observations To	Positions of the Radiant Points. R.A.	N. Decl.	By the nearest Fixed Stars.
			h m	h m	°	°	
23*	Prof. A. Hall	Washington, U.S.	6 25	8 0	355	43	Approx. place by projections on a globe [*A. J. S.*]
24	Ph. Breton	Grenoble, France	7 0	8 0	[0	40]	Between Cassiopeia and the square of Pegasus [*C. R.* No. 23].
25	J. W. Durrad	Leicester	...	...	[0	50]	South-west of Cassiopeia [communicated by Mr. W. F. Denning].
26		France	...	...	[10	48]	South of Cassiopeia [ditto].
27	Mr. Watkins Old	Hereford	...	...	[10	50]	A little south of Cassiopeia [ditto].
28*	Commander Wharton	Malta	at	7 45	10	37	Not far from the star β Andromedæ, nearly in the zenith at the time stated [*M. N.*, No. 3].
29*	Prof. Eastman	Washington, U.S.	after	8 0	12	38	Centre at μ Andromedæ; radiant area a circle 8° in diameter [*A. J. S.*]
30*	J. M. Wilson	Rugby	5 0	6 45	12	48	The principal centre; radiant area a triangle included between γ and ζ Andromedæ, and ξ Cassiopeiæ [*M. N.*, No. 2].
31*	G. H. H.	Birkenhead	5 30	10 0	12	50	South of μ Cassiopeiæ [communicated by Mr. W. F. Denning].
32*	B. V. Marsh	Philadelphia, U.S.	6 15	11 45	15	30	Principal radiant point, in a large radiant area [*A. J. S.*, see No. 94].
33*	Aug. Tacchini	Mazzarino, Sicily	at	9 30	15	53	[Near θ Cassiopeiæ; *C. R.*, No. 26.]
34*	A. D. P.	Newcastle-on-Tyne	6 0	6 30	16	35	At or close to Mirach [β Andromedæ, Local

									meda [*M. N.*, No. 2].
35*a**	Prof. R. Ball	...	Dublin, Ireland	...	[6 0	9 0?]	19	45	Coincided nearly with 46 [ξ] Andromedæ, though the radiant varied slightly [S.]
36*	V. Fasel	...	Morges, Switzerland	...	7 45	10 0	19	55	A few degrees south of δ Cassiopeiæ [star's approx. place for 1872, R.A. 19°·5, N. Decl. 59°·5, *M. N.*, No. 2].
36*a**	C. E. Burton	...	Near Dublin, Ireland	...	about	7 45	19·5	44·8	A very exact observation [*M. N.*, No. 3].
37*	Prof. Harkness	...	Washington, U.S.	...	8 0	10 0	20	39	About halfway between μ and γ Andromedæ [A. J. S.]
38	M. Roch	...	Bertignat, Puy de Dome, France		6 30	8 30	[20	45]	About midway between Cassiopeia and Triangulum [*C. R.*, No. 23].
39*	W. H. Wood	...	Birmingham	...	6 0	10 15	20	45	The principal radiant; from tracks of meteors mapped [communicated by Mr. W. H. Wood].
40*	J. Birmingham (of Tuam, Ireland)	...	Scarborough	...	at	6 0	21·7	45·5	Centre of a circular radiant area 3° in diameter; some meteors erratic; one stationary at R.A. 24°, N. Decl. 46°·7 [Letter to Prof. Peters; D.]
41*	Prof. Palisa (of Pola, Austria)	...	Hamburg, Germany	...	...	...	22	43?	Near χ Andromedæ [*Mechanic's Mag.*, Dec. 21st, 1872]. In Perseus [Prof. Littrow's Report on the Star-shower; D.]
42*	Prof. Karlinski	...	Cracow, Poland	...	10 10	11 0	22	43	[Near χ Andromedæ; Prof. Littrow's Report; D.]
42*a**	C. E. Burton	...	Near Dublin, Ireland	...	about	8 15	22·4	43·6	A very exact observation; radiant apparently shifting its place since $7^h\ 15^m$ [see Nos. 34*a*, 36*a*; *M. N.*, No. 3]
43*	J. F. Schmidt	...	Athens, Greece	...	5 30	14 30	22·5	42·5	Not far from γ Andromedæ [near the star B.A.C 501 (Heis); and υ Andromedæ; H.]
44*	W. Andrews	...	Coventry	...	5 55	6 0	22·5	47	About 1° south of υ Persei; at $7^h\ 30^m$ the radiant appeared to have shifted about 2° towards the south [*Astronomical Register*, vol. xi. p. 14, Jan. 1873].

Ref. No.	Observer.	Place of Observation.	Local Time of Observations From	To	Positions of the Radiant Points. R.A.	N. Decl.	By the nearest Fixed Stars.
			h m	h m	°	°	
45*	Prof. S. Newcomb	... Washington, U.S.	... 6 50	7 0	23	41·5	Close to the star 50 [υ] Andromedæ; uncertainty of the position about 2°. Radiant less well defined after 7^h [A. J. S.]
46*	Prof. de Gasparis	... Naples, Italy	... about	7 0	23	43	Near γ [χ] Andromedæ [*C. R.*, No. 23].
47*	Herr Bornitz	... Lichtenberg, Germany	... about	7 0	23	43	Provisional estimation of the radiant point near χ Andromedæ. Forty-six meteors mapped in 23^m [H.]
48*	Prof. C. Bruno	... Mondovi, Italy	... 6 18	14 15	23	44	From 61 meteors mapped by Sig. Chiavarino [see No. 71. D.]
49*	Herr Engelmann	... Leipzig, Germany	... Mean Hour of the Observations.	8 32	22	43	From courses of meteors mapped and projected by Herr Weinek. Mean position of the observations at R.A. 23°, N. Decl. 43°·3 [D.]
50*	Herr Weinek	... Leipzig, Germany	...	...	23·3	42·8	
51*	Dr. Bruhns	... Leipzig, Germany	...	...	23·8	44·1	
52*	Prof. V. Eugenio	... Matera, Italy	... 10 0	10 30	23·5	44	Near γ [or χ] Andromedæ. From courses of meteors mapped. Another radiant point by eye-estimations [see No. 91. D.]
53*	Prof. G. Forbes	... Glasgow, Scotland	... 7 0	10 0	23·7	46	From mapped courses of 112 meteors near the radiant point. One stationary at R.A. 25°, N. Decl. 46°. Radiation generally good [*M. N.*, No. 6].
54*	Prof. Respighi	... Rome, Italy	... 7 15	9 54	24	46	Near $\upsilon\varphi$ Persei; General radiation very exact [D.]
55*	Prof. E. Heis	... Münster, Germany	... 8 0	9 0	24	50	At φ Persei; halfway between γ Andromedæ and α Cassiopeiæ [H.]
56*	E. Neu	... Essen, Germany	... ...	...	24	50	Centre φ Persei; area a circle on the line joining γ Andromedæ and α Cassiopeiæ as diameter [H.]
57*	Prof. H. A. Newton	... Newhaven, U.S	... 6 38	8 48	24·5	43·5	Central radiant point. Area apparently 8° or

59*	Correspondent of Dr. Heis		Witten, Germany	...	6 30	10 0	25	42	Radiant in the latter part of the shower. A little west of γ Andromedæ [see No. 87; H.]
60*	Prof. A. C. Twining	...	Newhaven, U.S.	...	7 33	8 45	25	43	Central radiant point. Area 8° long in R.A., 3° broad in Decl. [*A. J. S.*]
61*	Prof. Lyman	...	Newhaven, U.S.	...	5 55	8 21	25	43	Centre of the radiant. Radiant most obviously scattered [*A. J. S.*]
62*	M. Rubenson	...	Christiania, Norway	...	about	9 0	25	47	In a late part of the watch [see No. 67. D.; letter from Prof. Mohn].
63*	Prof. Klinkerfues	...	Göttingen, Germany	...	7 30	10 30	26	37	From paths of 81 meteors mapped [H.]
64*	L. Swift	...	Rochester, New York, U.S.	...	10 0	11 0	26	39	In the latter part of the watch; at $\frac{1}{4}$ (γ, β) Andromedæ [see No. 76. *A. J. S.*]
65*	Mr. Barber	...	Derby	...	...	...	26	44	[*M. N.*, No. 2; Mr. Hind; radiant of Biela's Comet in 1866 at R.A. 25$\frac{1}{4}$°, N. Decl. 42°.]
65*a*	Dr. J. W. Moore	...	Dublin, Ireland	...	a few minutes after	6 0	26	44	A short distance north-west of Almach [γ] in Andromeda; first rough position at 5^h 50^m, halfway between Cassiopeia and the Pleiades [S.]
66*	Prof. Fearnley	...	Christiania, Norway	...	8 25	9 3	27	43	Centre of radiant; area a circle 3° in diameter [D.; letter from Prof. Mohn].
67*	Prof. Mohn	...	Christiania, Norway	...	about	8 30	27	45	Close to γ Andromedæ; in the early part of the watch [see No. 62. D.; ditto].
68	Herr Glauser	...	Sachseln, Switzerland	...	9 0	10 0	[27	56]	Between Perseus and Cassiopeia; radiant very distinct [W.]
69	W. B. Shorto	...	Suez, Egypt	...	...	...	[28	41]	General radiant centre between Aries, Perseus and Cassiopeia [communicated by Mr. W. F. Denning].
70*	G. Lespiault	...	Bordeaux, France	...	5 0	11 0	28	46	About $\frac{1}{2}$ (γ, 51) Andromedæ [see also No. 78; *omit* No. 19 of the previous list; 51 Androm. (υ Persei), apparently misprinted, 50 Androm. in *Comptes Rendus*. C. R. No. 23.]

Ref. No.	Observer.	Place of Observation.	Local Time of Observations From	To	Positions of the Radiant Points. R.A.	N. Decl.	By the nearest Fixed Stars.
			h m	h m	°	°	
71*	Prof. C. Bruno ...	Mondovi, Italy ...	6 50	14 0	28	45	At ½ (γ Andromedæ, ϕ Persei); by repeated eye-estimations during the watch; radiant perhaps double [see No. 48; ϕ appears misprinted, γ Persei. D.]
72	H. W. Hollis ...	Newcastle, Staffordshire ...	7 40	8 17	[28	55]	Between Perseus and Cassiopeia, *The Times*, Nov. 30, 1872.
73*	Correspondent of Dr. Heis	Pöblitz, Zwickow, Germany ...	5 0	10 0	28	55	In Perseus [near χ Persei]; carefully observed; radiant area a circle of 2° or 3° radius round this point [H.]
74*	L. Swift ...	Rochester, New York, U.S. ...	9 0	10 0	29	41·8	Exactly at γ Andromedæ, during the early part of the watch [see No. 63. *A. J. S.*]
75*	W. C. Taylor ...	Haddonfield, New York, U.S. ...	7 0	8 0	29	42	Best general position at γ Andromedæ [*A. J. S.*]
76*	Prof. Dorna ...	Turin, Piedmont, Italy ...	6 0	9 0	29	42	Radiant at γ Andromedæ [D.]
77*	S. Tromholdt ...	Svanholmsminde, Jutland, Denmark	7 30	11 30	29	42	At or close to γ Andromedæ [H.]
77*a*	A. Forbes ...	Culloden, Inverness, Scotland ...	6 0	10 20	29	44	Between Perseus and Cassiopeia, and only 2° or 3° north of Almach [γ] in Andromeda [S.]
78*	M. Glotin ...	Bordeaux, France ...	5 0	9 30	29	47	[Nearly between γ Andromedæ and $\upsilon\phi$ Persei (51, 54 Andromedæ); see No. 70. *C. R.*, No. 23.]
79*	Correspondent of Prof. Heis	Dantzig, Germany ...	5 30	10 0	30	42	Well-observed position near γ Andromedæ [H.]
80*	Prof. Them. Zona ...	Caltanisetta, Sicily ...	10 0	14 15	30	44	Exact place of radiant [adopted in this synopsis] near γ Andromedæ [letter from Prof. Zona; D.]
			10 0	13 0	32	43	Near γ Andromedæ; from map of meteor-tracks [apparently a provisional place. T.]
81*	N. von Konkoly ...	O'Gyalla Komorn, Hungary ...	7 30	10 0	30	45†	Centre of the radiant; $\pm 2°$ in R.A. and $\pm 5°$ in Decl.; radiant space the triangle formed by γ Andromedæ, θ Cassiopeiæ,

									Andromedæ; fixed throughout the shower; radiant area between Perseus, Cassiopeia, and Andromeda [*C. R.*, No. 23].
83	A. Secchi	...	Rome, Italy	...	8 0	9 0	[31	29]	Well-defined region between Aries, Triangulum, and Musca [D.]
84*	A. Secchi	...	Rome, Italy	...	about at	9 0	31	34	A small area 2° or 3° diameter near β, γ Trianguli [ibid].
85*	A. Secchi	...	Rome, Italy	...	at	11 0	31	57	Near χ Persei; lasting but a short time [ibid].
86	A. Secchi	...	Rome, Italy	...	12 0	13 0	[35	38]	Midway between Triangulum and Caput Medusæ [ibid].
87*	Correspondent of Dr. Heis		Witten, Germany	...	5 30	6 30	31	49	Between δ and φ Persei; in the early part of the watch [see No. 59. H.]
87*a*	R. Tyrer	...	Mansfield, Notts.	From dusk	[5 0]	11 0	32	57	Near the great cluster [χ] in Perseus [S.; MS. note].
88*	Prof. Ign. Galli	...	Velletri, Italy	...	7 0	12 0	40	45	Centre of a rather wide radiant; area between α, β Persei, and γ Andromedæ [D.]
89*	Prof. Tacchini	...	Palermo, Sicily	...	at	11 0	40·1	[46·5	[Near δ Persei.] From the courses of short meteors only near the radiant [T. and D.]
90*	Prof. Boltshausen	...	Catania, Sicily	...	about	8 0	44	40	In Perseus, principally about the head of Medusa [β Persei. T. and D.]
91*	Prof. V. Eugenio	...	Matera, Italy	...	10 0	10 30	44	38·5	ϱ Persei. From careful eye-estimates of the meteor-flights descending thence vertically, few appeared unconformable to that point [see No. 52. D.]
92*	M. Courtois	...	Muges, Lot et Garonne, France		5 0	11 0	45	40·5	Radiant round Algol [*C. R.*, No. 23].
93	M. Alby	...	Girgenti, Sicily	...	at	8 0	52	35	[Near south foot of Perseus; T.] A wide circle on a line from Cassiopeia to Orion comprised the radiant area [*C. R.*, No. 23].

† In Prof. Denza's Memoir the Decl. is printed 55°; but this is outside the triangular space described as the radiant area.

Ref. No.	Observer.	Place of Observation.	Local Time of Observations From (h m)	To (h m)	Positions of the Radiant Points. R.A. (°)	N. Decl. (°)	By the nearest Fixed Stars.
93*a*	H. A. Boys ...	Patras, Greece ...	10 30	12 0	60	40	About 5° W.N.W. of the zenith (Patras, lat. 38° 17′, long. 21° 46′) at midnight [in Perseus. S.]

Positions of Radiant Areas.

94	B. V. Marsh ...	Philadelphia, U.S. ...	6 10	11 45	347 42	20 40	Major axis	Radiant space oval, or oblong; about 50° by 30° [see No. 32. *A. J. S.*]
					5 16	47 12	Minor axis	
95*	Prof. Bellucci ...	Perugia, Italy ...	7 0	10 0	24 27·5	43 42		Extreme points of a linear radiant region [centre at R.A. 25°·7, N. Decl. 42°·5. D.]
96	F. Denza ...	Moncalieri, Piedmont, Italy ...	6 0	10 0	25 29 34	38 46 54		Extreme and middle points of a narrow radiant-region, more elongated in Decl. than in R.A. [see No. 21 in previous list. D.]
97	Prof. Missaghi ...	Cagliari, Sardinia, Italy ...	8 0	8 30	[20	50]		Radiant in the region between Cassiopeia, Perseus, and Andromeda [centre of this space near $\upsilon\ \phi$ Persei. D.]
98	Sig. P. Ovado ...	Savigliano, Piedmont, Italy ...	at	9 0	[25	40]		A region in Cassiopeia, Andromeda, Perseus, and Aries [centre about at $\gamma\ \tau$ Andromedæ. D.]
99	Prof. A. Gilliéron ...	Ste Croix, Switzerland ...	Evening and night		[47	49]		Radiating from about the direction of the constellation Perseus [position at $\alpha\ \iota$ Persei. W.]
100	M. Bourdeau ...	Pau, France ...	6 30	10 30	[47	49]		Radiant centre in Perseus: few unconformable meteors [position as in the last observation. *C. R.*, No. 23].

Ephemeris of the Five Inner Satellites of Saturn.
By A. Marth, Esq.

Angles of position at the Planet's centre, at 20^h Greenwich Sidereal Time.

1873.	Mimas.	Encel.	Tethys.	Dione.	Rhea.
June 13	246°	71°	280°	291°	24°
14	262	287	104	92	96
15	271	232	288	242	150
16	278	102	112	318	268
17	286	17	298	105	303
18	296	276	126	266	77
19	316	155	318	38	110
20	358	90	156	123	237
21	50	310	2	279	282
22	74	261	210	78	13
23	86	119	52	177	94
24	94	73	245	293	143
25	102	289	74	94	266
26	111	237	261	247	300
27	123	103	86	324	75
28	150	25	270	106	108
29	204	277	94	268	231
30	243	161	278	45	280
July 1	260	91	101	126	1
*2	270	314	285	280	93
3	278	265	110	81	137
4	285	119	295	188	264
5	295	75	122	295	297
6	312	290	310	95	71
7	351	241	145	250	107
8	46	104	347	330	224
9	72	32	195	108	279
10	85	278	40	269	349

* In the night of July 2 *Saturn* passes near a star 8^m, the position of which does not seem to have been determined accurately anywhere, as it is only found in the Markree Catalogue, vol. i. p. 16. 20^h 10^m 51^s, 110° 22′·6, f. 1850. If the apparent place hence deduced (20^h 12^m 13^s·48, 110° 18′ 23″·2), and also the *Nautical Almanac* place of the planet were correct, the nearest approach would occur at 22^h 13^m G. Sid. T., when the star would appear in pos. 165°·8 at the distance of 55″·7 from ♄'s centre.

1873.	Minas.	Encel.	Tethys.	Dione.	Rhea.
	°	°	°	°	°
July 11	94	169	238	51	91
12	101	92	69	129	132
*13	109	318	257	282	262
14	121	266	83	82	295
15	146	122	268	198	67
16	197	77	92	297	105
17	240	292	276	96	214
18	258	244	99	253	277
19	269	105	283	339	330
20	277	39	107	109	90
21	284	279	292	271	128
22	294	177	118	57	260
23	310	93	306	134	293
24	346	323	137	283	63
25	40	267	335	84	104
26	69	125	179	208	205
27	83	79	27	300	276
28	92	293	229	98	332
29	100	247	63	255	88
30	108	106	253	347	125
31	120	45	80	111	257
Aug. 1	141	280	265	272	291
2	190	186	90	62	57
3	236	94	273	139	102
4	256	328	97	284	193
5	268	268	281	86	274
6	274	127	105	217	324
7	283	80	289	303	86
8	293	295	115	99	121
9	307	249	301	257	254
10	339	107	130	358	289
11	33	50	324	113	50
12	66	281	165	274	101
13	81	193	11	65	182
14	91	96	216	145	273

* In the afternoon of July 13 *Saturn* passes near a star 9^m, the apparent place of which, deduced from Arg. Oe^2 20357, is found to be $20^h\ 9^m\ 9^s{\cdot}88$, $110^\circ\ 28'\ 28''{\cdot}0$.

1873.	Mimas.	Encel.	Tethys.	Dione.	Rhea.
	°	°	°	°	°
Aug. 15	99	333	55	286	318
16	107	269	247	87	84
17	118	130	76	224	118
18	138	82	262	306	251
19	182	298	87	100	287
20	231	251	271	260	43
21	254	109	95	7	99
22	266	54	279	115	171
23	274	282	103	275	271
24	282	200	287	68	313
25	291	96	112	151	82
26	305	339	297	288	116
27	333	270	125	89	247
28	25	134	316	229	286
29	62	83	152	310	34
30	79	299	355	102	97
31	90	253	202	261	161
Sept. 1	98	110	44	16	270
2	106	59	240	118	309
3	117	283	70	276	79
4	134	207	258	71	114
5	173	97	84	158	240
6	224	346	268	289	284
7	251	271	93	90	23
8	264	137	276	234	96
9	273	84	100	314	152
10	281	291	284	103	267
11	290	255	109	263	305
12	303	111	294	25	76
13	328	59	120	120	111
14	16	284	309	277	235
15	58	212	141	73	282
16	77	98	339	165	11
17	88	351	184	291	94
18	96	272	30	91	144
19	104	140	230	238	265
20	115	85	64	318	301
21	130	303	254	104	73

1873.		Mimas.	Encel.	Tethys.	Dione.	Rhea.
		°	°	°	°	°
Sept.	22	163	256	80	265	109
	23	216	113	265	32	228
	24	247	62	90	122	280
	25	262	285	274	278	359
	26	272	216	98	76	92
	27	279	99	282	172	137
	28	288	356	106	292	263
	29	300	273	290	92	298
	30	322	143	116	242	69
Oct.	1	5	86	303	322	107
	2	51	305	132	105	219
	3	74	257	326	266	278
	4	86	114	166	38	347
	5	95	64	12	124	90
	6	102	286	217	279	131
	7	112	220	55	78	260
	8	126	100	247	180	295
	9	154	1	75	294	63
	10	206	274	262	93	105
	11	242	146	87	245	208
	12	259	87	271	326	277
	13	269	306	95	106	336
	14	278	258	279	267	88
	15	286	115	102	43	127
	16	297	66	287	127	257
	17	314	287	111	280	292
	18	352	223	297	79	57

These angles of position are reckoned in the usual way from the circle of declination. In comparing them with estimations reckoned from the direction of the minor axis of the ring, about 8° must be subtracted.

The distances of the satellites, expressed in semi-diameters of the ball, vary between the limits

	1·1	1·4	1·8	2·2	3·1
and	3·1	4·0	5·0	6·4	8·9

the form of their apparent orbits being very nearly symmetrical with the outline of the ring.

List of Co-ordinates of Stars within or near the Milky Way.

By A. Marth, Esq.

The second half of the list of co-ordinates requires but little explanation. The extended breadth of the Milky Way in Heis's representations of it in his *Atlas Cœlestis Novus* has induced me to extend the computation of co-ordinates to all the leading stars between the galactic polar-distances 70° and 110°. Where the magnitudes do not depend on either Argelander's or Heis's estimations or on those of Sir John Herschel in his paper, "On a Review and Rearrangement of the Constellations," &c., in the twelfth vol. of the *Memoirs*, they are those of the B.A.C. and enclosed in brackets. In consequence of the want of a trustworthy catalogue of magnitudes of Southern stars, some stars may have been inserted in the list which scarcely deserve it.

(*Continued from page* 14.)

x in.	*y* in.	Mag. in.	Star.	B.A.C.
36·28	7·47	2·7	$\varkappa$ Orionis	1843
·32	5·96	4·7	5 Monoc.	2015
·36	1·15	1	Procyon	2522
·37	5·25	5	10 Monoc.	2094
·66	4·91	6	..	wanting
·70	2·92	4·3	22 Monoc.	2358
·78	1·80	5·7	δ' Can. Min.	2480
·78	6·94	5·3	3 Monoc.	1936
36·79	5·43	4·3	11 ,,	2105
37·30	0·96	5·7	ζ Can. Min.	2612
·32	7·50	3·7	η Leporis	1901
·36	3·86	6	..	wanting
·48	0·45	5	12 H. Can. Min.	2673
·48	5·07	6	..	wanting
·49	4·58	6	..	wanting
·68	6·63	5	..	wanting
·68	7·15	5	θ Leporis	1959
·92	3·01	6	..	2437
·94	7·34	5	17 Leporis	1955
37·97	2·18	5·3	25 Monoc.	2513
38·12	0·87	5·3	28 ,,	2668
·27	4·82	4·3	θ Canis	2264
·47	3·78	6	..	wanting
·52	5·36	5	11 Canis	2221
·60	0·72	4·7	29 Monoc.	2725
·60	1·65	6	..	wanting
·61	6·72	2·7	β Canis	2061
·67	4·93	5	μ ,,	2273

x in.	y in.	Mag. in.	Star.	B.A.C.
38·88	5·64		Sirius	2213
39·01	2·57	4·3	26 Monoc.	2542
·13	4·76	4·3	γ Canis	2319
·15	6·24	5	ν^2 „	2171
·20	5·22	4·7	ι „	2274
·24	0·81	cl.	VI. 22 = h. 496	(2766)
·24	0·10	3·7	30 Monoc.	2825
·42	4·24	6	..	wanting
·63	1·49	6	..	wanting
·63	6·00	cl.	Mess. 41	(2217)
·67	3·40	5·7	..	wanting
·74	3·28	cl.	VIII. 38 = h. 459	2511
·80	6·65	5	ξ^2 Canis	2160
·81	6·82	5	ξ^1 „	2132
39·95	2·77	5	4 Puppis	2573
40·16	4·34	5·7	..	wanting
·39	1·70	5	19 Puppis	2750
·42	5·98	5	o' Canis	2267
·56	5·59	3·3	o^2 „	2318
·77	5·00	5	..	wanting
·84	7·85	2·7	ζ Canis	2051
40·99	2·79	5·3	..	2666
41·03	5·03	5 ? var.	29 Canis	2417
·03	4·44	5·7	..	wanting
·03	4·16	5	..	wanting
·10	5·08	4·7	30 Canis	2418
·13	5·62	2	δ „	2345
·21	4·31	6 ? var.	..	2497
·26	6·03	4	22 Canis	2309
·33	5·41	4·7	28 „	2391
·38	6·25	1·7	ε „	2293
·39	2·50	5	16 Puppis	2736
·47	7·74	4·3	λ Canis	2109
·49	6·98	5	10 „	2214
·53	0·38	4·7	12 Hydræ	2975
·54	8·04	4	δ Columbæ	2066
·63	4·36	5	..	2525
·67	3·38	4·7	11 Puppis	2652
·81	3·88	3·7	ξ Argûs	2602
·86	6·90	4	$\varkappa$ Canis	2246
·87	2·12	6	..	wanting
·89	4·49	4·3	..	2530·31
·97	3·95	5	..	2594

x in.	y in.	Mag. in.	Star.	B.A.C.
41·98	5·30	2·7	η Canis	2458
42·07	4·78	5·3	..	2508
·19	3·14	3	15 Argûs	2728
·37	4·53	4	..	2562
·42	5·23	5	..	2484
·80	1·78	6	..	wanting
42·93	4·18	5·7	..	2655
43·22	6·32	3	π Argûs	2414
·25	5·40	(6)	..	2523
·53	6·84	(5)	..	2355
·54	4·85	(5)	..	2629
·55	5·51	(6)	..	2536
·71	8·19	3·7	ν Argûs	2188
·90	2·63	5·7	..	2932
·92	2·02	5	..	3010
·93	5·44	4·3	..	2580
·95	5·63	4·3	..	2554
43·96	3·67	(5)	..	2802
44·17	1·20	5	..	3121
·22	4·27	(5)	..	2774
·24	5·29	(5)	..	2635
·41	5·80	(4½)	..	2570
·47	4·20	(5)	..	2795
·52	5·49	4	..	2634
·56	6·50	3·7	σ Argûs	2482
·56	2·96	4	..	2964
·62	0·62	5·7	..	3195
·63	7·19	(5)	..	2392
·67	5·06	2·7	ζ Argûs	2710
·79	3·35	(5)	..	2935
44·92	7·34	(5)	..	2389
45·23	5·72	(6)	..	2661
·36	8·33	3·3	τ Argûs	2256
·46	6·20	(4½)	..	2620
·53	9·22		Canopus	2096
·66	0·35	5	θ Antliæ	3332
·84	6·26	(4)	..	2644
45·91	4·40	(5)	..	2926
46·01	5·72	2	γ Argûs	2755
·08	2·58	(5½)	..	3165
·10	6·43	(5)	..	2642
·12	6·24	(5)	..	2670
·24	2·75	(5)	..	3163

x in.	*y* in.	Mag. in.	Star.	B.A.C.
46·28	2·00	(5½)	ε Antliæ	3244
·46	5·50	(5)	..	2823
·55	4·79	4·7	..	2947
·55	4·38	(5½)	..	3014
·57	4·57	4·7	..	2981
·72	3·64	2·7	λ Argûs	3126
·75	6·68	4·3	χ „	2665
·75	4·52	(6)	..	3020
46·93	2·63	4·3	ψ Argûs	3257
47·00	3·77	(5½)	..	3142
·10	5·12	(6)	..	2972
·12	5·46	(5½)	..	2915
·15	4·25	(5)	..	3110
·50	2·87	(5½)	..	3302
·51	5·60	4·3	*o* Argûs	2950
47·87	5 76	2·3	δ „	2979
48·03	4·50	(5)	..	3187
·15	3·00	(6)	..	3370
·17	7·43	cl.	*h.* 3111	2687
·22	2·84	(6)	..	3396
·23	5·95	(5)	..	2998
·26	3·84	(4)	..	3300
·27	6·79	2	ε Argûs	2832
·39	7·27	(5½)	..	2770
·43	4·19	(5½)	..	3280
·47	1·90	4·7	..	3509
·59	6·46	(5)	..	2962
·66	1·67	(5)	..	3552
·66	4·99	3	ϰ Argûs	3213
·79	6·07	(4)	..	3073
48·81	6·00	(4)	..	3089
49·00	5·77	4·3	..	3149
·12	5·12	3·7	..	3269
·15	5·70	2·7	ι Argûs	3186
·32	2·08	(6)	..	3613
·38	4·29	4·3	φ Argûs	3410
·42	3·46	(5½)	..	3499
·43	0·25	(5½)	..	3755
·45	7·48	4·7	β Volantis	2863
·48	5·40	(5)	..	3289
·49	6·24	4·7	..	3152
·71	8·04	4·7	ε Volantis	2773
·78	2·55	4·7	..	3644

x in.	y in.	Mag. in.	Star.	B.A.C.
49·85	5·64	(5)	..	3320
·96	6·93	4·7	α Volantis	3114
49·98	4·00	(5)	..	3536
50·11	5·74	4·3	..	3353
·11	6·37	(5)	..	3249
·12	4·16	(5)	..	3546
·17	2·62	3	μ Argûs	3702
·18	5·10	cl.	*h.* 3224	3447
·43	4·34	(5)	..	3589
·46	6·11	3·3	v Argûs	3365
·55	4·53	(5)	..	3594
·58	5·11	3·7	..	3526
·59	2·00	(6)	..	3796
·61	7·23	2	β Argûs	3177
·84	4·47	(5)	..	3655
·92	5·00	4	..	3619
50·97	7·72	(5)	..	3136
51·03	4·49	var.	η Argûs	3695
·15	4·25	4·3	..	3740
·21	5·74	(5)	..	3586
·40	5·36	3·3	θ Argûs	3686
·45	4·08	cl.	*h.* 3315	3802
·48	6·61	3·7	ω Argûs	3516
·54	3·16	(4)	π Centauri	3866
·65	1·72	(6)	..	3951
·72	4·78	(6)	..	3805
51·73	4·67	(6)	..	3820
52·06	7·20	4·7	..	3585
·34	0·49	(5½)	..	4062
·40	4·68	3·7	λ Centauri	3941
·55	4·26	(5½)	..	3986
·65	7·93	(5)	γ Chamæl.	3660
·77	2·10	3	δ Centauri	4087
·79	5·35	4·3	..	3984
52·92	2·41	4·7	ϱ Centauri	4103
53·14	4·85	(4½)	η Crucis	4078
·18	3·66	3·7	δ ,,	4120
·37	3·98	4·7	ε ,,	4158
·37	4·70	(5)	ζ ,,	4133
·39	1·93	4·7	σ Cent.	4197
·44	5·49	(5½)	ε Muscæ	4129
·48	7·56	(5)	ε Chamæl.	4048
·54	4·50	1·3	α Crucis	4187

x in.	y in.	Mag. in.	Star.	B.A.C.
53·57	3·30	1·7	γ Crucis	4215
·70	1·58	(5)	τ Cent.	4251
·70	7·75	4·7	β Chamæl.	4131
·76	6·30	4·7	γ Muscæ	4224
·82	5·70	3·3	α ,,	4245
·83	1·66	2·7	γ Cent.	4264
·89	4·46	cl.	h. 3407	
53·98	5·49	3·7	β Muscæ	4280
54·02	3·81	1·3	β Crucis	4289
·17	3·95	cl.	$\varkappa$,, = h. 3435	4320
·20	6·04	cl.	h. 3444	4349
·21	3·31	4·7	..	4325
·23	6·19	4·7	δ Muscæ	4353
·44	4·95	(5½)	θ ,,	4381
·53	5·48	(5)	η ,,	4426
·66	1·88	(5)	ξ^2 Cent.	4379
·79	4·84	(6)	..	4475·69
·86	4·13	(6)	..	4461·63
·90	7·37	(5)	θ Apodis	4660
54·94	0·59	(5)	..	4409
55·15	7·95	4·7	α Apodis	4833
·21	1·47	cl.	ω Cent.	4485
·58	2·73	3	ε ,,	4549
·87	4·23	1·3	β ,,	4669
55·87	2·37	(5)	..	4580
56·37	1·65	3	ζ Cent.	4638
·37	5·40	3·7	α Circini	4835
·41	0·66	4	μ Cent.	4602
·45	4·02	4·7	..	4749
·45	0·51	4	ν Cent.	4601
·53	3·61	4·7	..	4735
·61	1·20	4·3	υ^1 Cent.	4654
·63	6·40	3·3	γ Triang. aust.	5005
·68	4·64	..	α Centauri	4832
56·76	0·67	4·3	φ ,,	4653
57·10	0·59	(5)	χ ,,	4681
·19	6·79	(5)	$\varkappa$ Triang.	5224
·19	6·21	(5)	ε ,,	5103
·24	1·66	4·3	ι Lupi	4734
·32	2·65	(5)	σ ,,	4801
·45	5·08	(6)	δ Circini	5004
·51	1·63	(5)	τ^2 Lupi	4770
·52	1·60	(5)	τ^1 ,,	4768

x in.	y in.	Mag. in.	Star.	D.A.C.
57·56	2·53	4·7	ϱ Lupi	4821
·69	4·72	4·7	β Circini	5011
·76	4·89	4·7	γ „	5044
·80	7·55	2·3	α Triang.	5578
·86	2·21	3	α Lupi	4839
·86	0·49	(5)	..	4759
·88	6·00	3·3	β Triang.	5233
·89	0·16	(5)	ψ Cent.	4745
57·91	4·04	(5½)	..	4977
58·09	1·13	3	η Cent.	4811
·27	3·51	4·3	ζ Lupi	4987
·51	1·68	(5)	o „	4892
·59	2·52	4·3	π „	4948
·61	2·93	4·3	$\varkappa$ „	4986
·71	0·48	4·3	..	4842
·78	1·72	3·3	β Lupi	4924
·78	5·29	(5½)	ι Normæ	5301
·88	2·28	4·7	λ Lupi	4973
·89	2·90	4·3	μ „	5028
·90	1·55	3·7	$\varkappa$ Cent.	4928
·91	4·00	(6)	..	5136
58·99	2·97	4	ν^1 Lupi	5049
59·08	4·35	(6)	..	5209
·16	4·76	(6)	..	5283
·19	8·06	4	η Pavonis	5963
·36	2·44	(4½)	ε Lupi	5056
·44	6·34	(4½)	η Aræ	5609
·72	2·76	4·3	..	5123
·77	7·38	4	δ Arae	5877
·78	1·74	4	δ Lupi	5046
59·91	2·82	4·3	..	5165
60·07	2·42	4·7	ι Lupi	5139
·08	6·15	4	ζ Aræ	5683
·12	4·43	(5½)	γ^1 Normæ	5404
·15	2·13	3·3	γ Lupi	5118
·18	4·50	4·3	γ^2 Normæ	5425
·28	1·16	(5)	φ^2 Lupi	5060
·30	1·03	4	φ^1 „	5054
·45	6·80	3·3	γ Aræ	5850
·53	3·47	4·7	δ Normæ	5323
·55	5·82	4·7	ε^1 Aræ	5697
·60	6·71	3·7	β „	5852
·61	5·92	(5)	ε^2 „	5713

x in.	y in.	Mag. in.	Star.	B.A.C.
60·72	4·31	4·3	ε Normæ	5472
·73	4·95	4·7	..	5561
·87	4·82	(6)	..	5558
·88	5·43	(6)	ϱ Aræ	5664
·89	−0·07	4·7	2 Lupi	5032
60·93	5·48	(6)	..	5689
61·14	1·16	5	ψ^1 Lupi	5160
·16	6·89	cl.	*h*. 3692	5945
·26	2·30	4·3	η Lupi	5292
·45	6·19	(5)	$\varkappa^1$ Aræ	5859
·61	1·34	5	χ Lupi	5227
·67	2·24	(4½)	θ ,,	5331
·68	6·27	3·3	α Aræ	5899
·70	0·41	4·3	σ Scorpii	5151
·76	1·55	5	ξ Lupi	5268
·86	0·11	4·3	3 H. Scorpii	5138
61·93	5·76	(6)	ι Aræ	5843
62·12	4·32	(4½)	ζ^1 Scorpii	5651
·14	4·34	4	ζ^2 ,,	5661
·21	7·26	4	θ Aræ	6105
·40	4·95	3·7	η Scorpii	5778
·41	0·84	4·7	ϱ ,,	5272
·69	2·65	(4)	..	5508
·69	0·15	5	δ Scorpii	5232
·73	3·71	3·3	μ^1 ,,	5638
·74	2·87	(5)	..	5538
·75	3·72	3·3	μ^2 ,,	5640
·84	0·17	5	A ,,	5250
·91	0·44	3	π ,,	5289
62·96	5·68	2·3	θ ,,	5935
63·05	7·03	(4½)	ε Telesc.	6140
·10	1·12	5	c Scorpii	5381
·27	3·17	2·7	ε ,,	5632
·29	7·52	4·3	α Telesc.	6240
·47	−0·02	2·3	δ Scorpii	5303
·66	5·71	3·7	ι ,,	6004
·67	3·62	(5)	..	5735
·73	1·08	3·3	σ Scorpii	5447
·74	5·42	3	κ ,,	5970
·78	4·85	3·3	ν ,,	5901
·79	1·91	3·3	τ ,,	5539
·82	1·41	1·3	α ,,	5498
·88	4·92	1·7	λ ,,	5915

x in,	y in.	Mag. in.	Star.	B.A.C.
63·91	3·28	5	..	5718
·99	−0·03	5	ω^2 Scorpii	5342
63·99	+0·58	var.	T ,,	(Nova of 1860)
64·00	−0·08	4·7	ω^1 ,,	5337
·08	−0·25	2	β ,,	5329
·09	+1·31	5	22 ,,	5501
·20	0·93	5	ϱ Ophiuchi	5477
·22	3·85	(5½)	..	5817
·24	5·46	3·7	..	6018
·36	−0·07	4	ν Scorpii	5382
·62	5·24	cl.	*h.* 3706	
·65	4·45	(5½)	..	5925
·68	0·42	5	ψ Oph.	5467
·71	0·90	5	ω ,,	5519
·84	4·60	cl.	Mess. 6	5960
·85	6·40	3·3	η Sagittarii	6186
64·93	3·89	5	*d* Ophiuchi	5881
65·16	3·08	5	A ,,	5808
·40	6·41	2·3	ε Sagittarii	6233
·45	0·23	5	φ Ophiuchi	5516
·59	3·14	3·3	θ ,,	5851
·60	0·76	5	24 Scorpii	5579
·73	5·35	3·3	γ Sagittarii	6115
·75	4·40	var. 4–6	X ,,	6008
·76	5·54	5·3	..	6145
·84	3·20	5	*b* Ophiuchi	5876
65·85	5·23	var. 5–6·5	W. Sagittarii	6107
66·00	2·65	5	ξ Ophiuchi	5844
·01	3·37	5	c^2 ,,	5907
·16	5·87	3·3	δ Sagittarii	6209
·39	3·06	..	Nova of 1604	
·65	−0·30	2·7	ζ Ophiuchi	5548
·69	3·58	5	$58^{}$,,	5987
·73	4·44	5	4 Sagittarii	6077
·73	4·66	6	9 ,,	6102
·78	7·65	5	..	6499
·79	1·61	2·3	η Ophiuchi	5781
·95	0·86	..	Nova of 1848	
66·97	7·48	3·3	ζ Sagittarii	6489
67·02	0·22	5	20 Ophiuchi	5637
·09	5·71	3	λ Sagittarii	6263
·18	6·56	3·7	φ ,,	6371
·48	7·47	3·7	τ ,,	6521

x in.	y in.	Mag. in.	Star.	B.A.C.
67·50	6·88	2·3	σ Sagittarii	6440
·53	4·72	4	μ „	6168
·57	1·70	4·7	ν Serpentis	5845
·60	2·66	3·7	ξ „	5949
·62	4·74	5	15 Sagittarii	6179
·89	5·14	5	21 „	6247
67·90	3·82	6	6 „	6086
68·10	4·64	cl.	Mess. 24	(6201)
·12	2·55	4·7	o Serpentis	5976
·13	6·53	5	ν^1 Sagittarii	6434
·17	6·56	5	ν^2 „	6441
·50	−0·07	5	30 Ophiuchi	5724
·51	6·53	4	ξ Sagittarii	6461
·54	6·87	4	o „	6507
·78	7·02	3	π „	6548
68·84	1·89	4·7	μ Ophiuchi	5953
69·03	4·71	4·7	2 H. Scuti	6279
·07	1·10	4·7	27 H. Ophiuchi	5890
·11	2·95	3·7	ν „	6078
·32	6·00	5	..	(6447)
·34	7·17	5	d Sagittarii	6584
·44	5·89	6	..	wanting
·49	2·96	5	τ Ophiuchi	6104
·62	0·18	5	41 „	5830
·63	7·24	4	ϱ Sagittarii	6619
69·99	7·08	4·7	v „	6621
70·09	0·63	5·3	..	5903
·20	2·39	5	ζ Serpentis	6085
·27	4·35	4·3	3 H. Scuti	6325
·30	4·73	5	4 H. „	6361
·43	7·99	5	e Sagittarii	6742
·47	6·38	6	..	wanting
·47	4·71	5	5 H. Scuti	6367
·72	0·14	4·3	σ Ophiuchi	5893
70·87	3·22	3	η Serpentis	6229
71·01	1·21	3·7	γ Ophiuchi	6020
·02	4·63	var. 4·7–9	R Scuti	wanting
·11	1·95	4·7	68 Ophiuchi	6101
·18	4·52	4·7	6 H. Scuti	6388
·22	5·06	5	7 H. „	6464
·23	0·84	3	β Ophiuchi	5996
·34	5·24	4·3	12 Aquilæ	6492
·37	1·74	4	67 Ophiuchi	6092

x in.	y in.	Mag. in	Star.	B.A.C.
71·42	1·99	4·3	70 Ophiuchi	6123
·53	0·86	cl.	...	(6012)
·62	1·59	5	66 „	6089
·62	5·36	3	λ Aquilæ	6526
·87	6·04	5·7	*f* „	6614
·95	2·58	5	74 Ophiuchi	6227
71·98	6·91	5	ϰ Aquilæ	6713

Corrigenda.

Page	7	x 6·20	17 Lyræ, B.A.C. 6553
	8	8·84	T Cygni, not τ
	9	12·02	y 6·86 instead of 6·87
		14·93	β Cephei, ·93 dropped out
	10	17·51	dele mag. 3·3
	11	20·45	cl. vi. 33 = h Persei
		20·52	cl. vi. 34 = χ „
		20·74	5 H Camelop., not 9 H
	12	25·28	o Persei, not o
		28·08	y 3·89 instead of 3·49
		28·13	16 Aurigæ instead of 14
	13	32·67	Mag. 4·7 instead of 5
		34·35	B.A.C. 1684 instead of 1730
		34·38	B.A.C. 2126 instead of 1684

5 line 25, read P.D. instead of Decl.

Note on Mr. Crossley's Paper on Meridian Marks for Transit Instruments. By Captain Noble.

With reference to the idea advanced by Mr. Crossley in his paper in the April number of the *Monthly Notices*, it may perhaps be worth mentioning that Maskelyne employed a cap with a lens of long focus, to slip over the object-glass of his transit, eighty or ninety years ago. He would appear to have derived his original notion from a Dr. Rittenhouse. Vide Smyth's *Celestial Cycle*, vol. i. (Prolegomena), p. 331.

On the Motion of Equatoreals in Right Ascension. By Wentworth Erck, LL.D., F.R.A.S.

Knowing the inconvenience most observers suffer from the uncertain movements of their instrument in right ascension, I desire to draw attention to two errors commonly committed in the transmission of the driving power from the clock to the polar axis, and to describe a new and very much simplified form of slow motion.

The power is usually communicated by a tangent-screw working in a circle, or sector, attached to the polar axis.

In order to prevent any play of the telescope in right ascension, both the tangent-screw itself must be free from end motion, and also the teeth of the sector must not have any power of moving in the thread of the screw.

The former condition is generally secured by causing the screw-shaft to work in V collars; the latter by having the thread of the screw of a V section, and keeping the screw pressed home by a spring into the teeth of the sector; or else by adjusting the distance of the screw from the centre of the circle so accurately that there shall be no play between the sector and the screw.

Both plans are objectionable: the spring, because it further requires that the screw should have a motion enabling it to alter its distance from the circle, and also because a very small pressure unintentionally applied to the end of a large telescope will suffice to overcome the pressure of the spring, when the screw, acting as a rasp on the teeth of the sector, will soon destroy them.

The other plan is far stronger and stiffer, but is also open to two objections:—

One is the great and uncertain friction inevitably attendant on the use of V collars; the uncertainty arising both from the uncertain degree to which the collars may be tightened up, and also the condition of the lubricating oil.

The other objection is the practical impossibility of so adjusting the distance of the screw from the circle as to prevent play without jambing the screw; and, even admitting the possibility of doing this for a single position of the circle and the screw, this will by no means suffice, for the adjustment must continue perfect for all positions of the circle and of the screw, which implies the absolute freedom from excentricity of both the circle and the screw, and also that the teeth of the circle shall be all of precisely the same depth.

To accomplish this in the case of a circle, and still more in the case of a sector, with deep teeth, would be, if not an impossibility, at least a most difficult work.

The instrument-makers tell us that the mere dividing of a circle with faint lines is no easy matter: how much more difficult would it be to cut out accurately every second space of 10′ to exactly the same depth all round.

Yet, if there be not this perfect freedom from excentricity in the screw, the sector, and the polar axis, there must be either motion between the sector and the screw, or else there will at times be applied to the screw the very most powerful form of clamp known, viz. a number of V teeth driven into V rings, producing a resistance which no clock could overcome.

The other common mistake alluded to consists in having several revolutions of the thread round the axis of the screw. These are not only useless, but injurious.

For, as the screw is a tangent to the circle, the intersections of the teeth of the circle with the thread of the screw will be the points where the secants of equal angles cut the tangent; but these spaces are constantly increasing from the centre toward each end of the screw, whereas the spaces between the revolutions of the thread are equal: therefore the central and extreme revolutions of the thread cannot fit the equal teeth of the sector, and, not fitting, they will jamb irregularly, and so tend to destroy each other.

There should be only three complete revolutions of the thread, the central revolution being at the point of contact of the circle with the tangent: in this case there will be always three teeth bearing uniformly against three revolutions of the thread.

All these difficulties I have avoided by using a square-threaded screw, working in a sector with square teeth. There is no attempt at fitting the teeth to the screw—if they did fit, they would soon wear loose—but the teeth of the sector are kept in close contact with the thread of the screw by a strong catgut band attached to the west end of the sector; which band, after passing round the circumference of the sector in a groove prepared for its reception just under the projecting teeth, and also passing over a fixed pulley in the plane of the sector and to the east thereof, carries at its other end a weight of about 20 lbs.

Thus there is no possibility of unintentional motion of the telescope in right ascension.

Further, the required motion in right ascension is produced by the weight aforesaid acting directly through the catgut band on the sector itself; so that the clock is not employed to move the telescope at all, but only to regulate, by the revolution of the screw, the rate at which the said weight shall move the telescope. This weight must be sufficient, not only to move the telescope, but also to overcome the pressure of a strong west wind against its upper end.

The slow motion in right ascension in my instrument is effected in the following manner:—

The driving-screw has a traversing motion, through plain collars, in the direction of its own length, to the extent of half an inch. The eastern end of the screw-shaft terminates in a hard steel knob, which abuts against the flat end of a large fine-threaded screw attached to a suitable part of the pedestal; and it

is always kept in contact with the said screw by the weight already mentioned acting on the driving-screw through the sector. Thus the smallest motion of the fine-threaded screw will be immediately responded to by the driving-screw, sector, and polar axis.

This fine screw is easily turned from any part of the observatory by means of cords passing over wheels on the end of a spindle connected by a pair of cog-wheels with the fine screw.

One turn of these wheels corresponds to thirty seconds of time ; so, the edge of the wheel being divided, you can with the greatest ease and accuracy measure small differences of right ascension up to eight or ten minutes of time ; while the motion is so smooth and reliable that you can split a star on the line almost quite as well and as certainly with the right ascension slow motion as with the micrometer-screw.

This apparatus has now been in use upwards of three years, during which it has received but little care or attention ; yet I have never once, under any circumstances, been disappointed in the immediate starting, and constant rate, of the driving-machinery.

In the ordinary form of construction the reserve-power of the clock is liable to be used up in overcoming internal resistance in the machinery ; whereas in the new form the entire reserve-power of the clock (which is about four times that absolutely necessary to move the instrument) is available to overcome external resistance.

In order to try the effect on the rate of a considerable resistance, I turned the telescope to P.D.=90 and R.A.=6 hrs. : in this position 14 lbs. attached to the telescope at a distance of 54 inches from the declination-axis did not produce a change of 10 seconds per hour in the rate ; while the friction of the whole machinery is so little that, although the moving parts weigh 8 cwt. a weight of 12 lbs., descending an inch per minute, sufficed to drive the clock and all attached machinery.

Sherrington Bray, Co. Wicklow,
19 May, 1873.

On a New Method of Observing the Transits of Venus.

By Richard A. Proctor, B.A. (Cambridge).

Mr. E. L. Garbett has communicated to me his views respecting a method of observing the approaching transits of *Venus*, which appears to offer considerable advantages. I hope to obtain from him, for our Supplementary Number, a full description of the method and its characteristics. For the present it may suffice to mention that he suggests the application of photography with

special reference to the middle of the transit,—that is, that stations should be selected where at the middle of the transit *Venus* will be most displaced by parallax from and towards the Sun's centre. This differs from Dr. De La Rue's original proposition, in which stress was laid, if I remember rightly, on the determination of the distance of *Venus* at mid-transit from the Sun's centre by the comparison of photographs taken during the whole progress of the transit. What Mr. Garbett proposes is that attention should be directed solely to the determination of the distance of *Venus* from the Sun's centre at the time of mid-transit by several photographs taken during a brief interval including that epoch.

The best available station for the purpose, in a geometrical sense, would be Bouvet Isle, south and somewhat west of Cape Town. But Cape Town would be an excellent station; and I cannot but express a hope that the necessary photographic appliances for this method will be provided there, in addition to those which can be favourably applied at that station for indicating the whole progress of the latter half of the transit. As our excellent late Secretary, Mr. Stone, is in command there, we may be sure that the fullest and most satisfactory use would be made of any appliances so provided.

Note on the Discovery of Minor Planet (131).

By E. Dunkin, Esq.

The following memorandum has been drawn up at the request of the Astronomer Royal, as an illustration of the successful working of the Convention relating to cable telegrams of important astronomical discoveries recently agreed upon between the Smithsonian Institution and the Directors of the Transatlantic Cable Companies.

On 1873, May 26, the following telegram was received by the Astronomer Royal from Dr. Henry, Secretary of the Smithsonian Institution, announcing the discovery of a new planet (131):—

"Planet sixteen fourteen south twenty one eighteen, motion due west eleventh."

These words were at once forwarded by telegraph to the Observatories of Paris, Berlin, Kiel, Vienna, and Pulkowa, and by post to the principal English Observatories.

The following communication has since been received by the Astronomer Royal from Dr. Förster, Director of the Observatory of Berlin:—

"With my best thanks for your telegraphic communication of the discovery of Planet (131), I beg to send you two observations taken at our Observatory:—

	Mean Time Berlin.	α appar.	δ appar.
	d h m s	h m s	° ′ ″
1873, May	29 12 54 26	16 11 20·23	−21 18 41·1
,,	31 13 2 21	16 9 16·06	−21 18 55·5″

The planet has been also observed in Europe, at the Observatory of Marseilles, by M. Borelly, and at the Observatory of Leipsig, by Dr. Börgen. It was discovered by Dr. C. H. F. Peters at Clinton, New York.

Kidbrooke, Blackheath,
1873, *June* 11.

Errata.

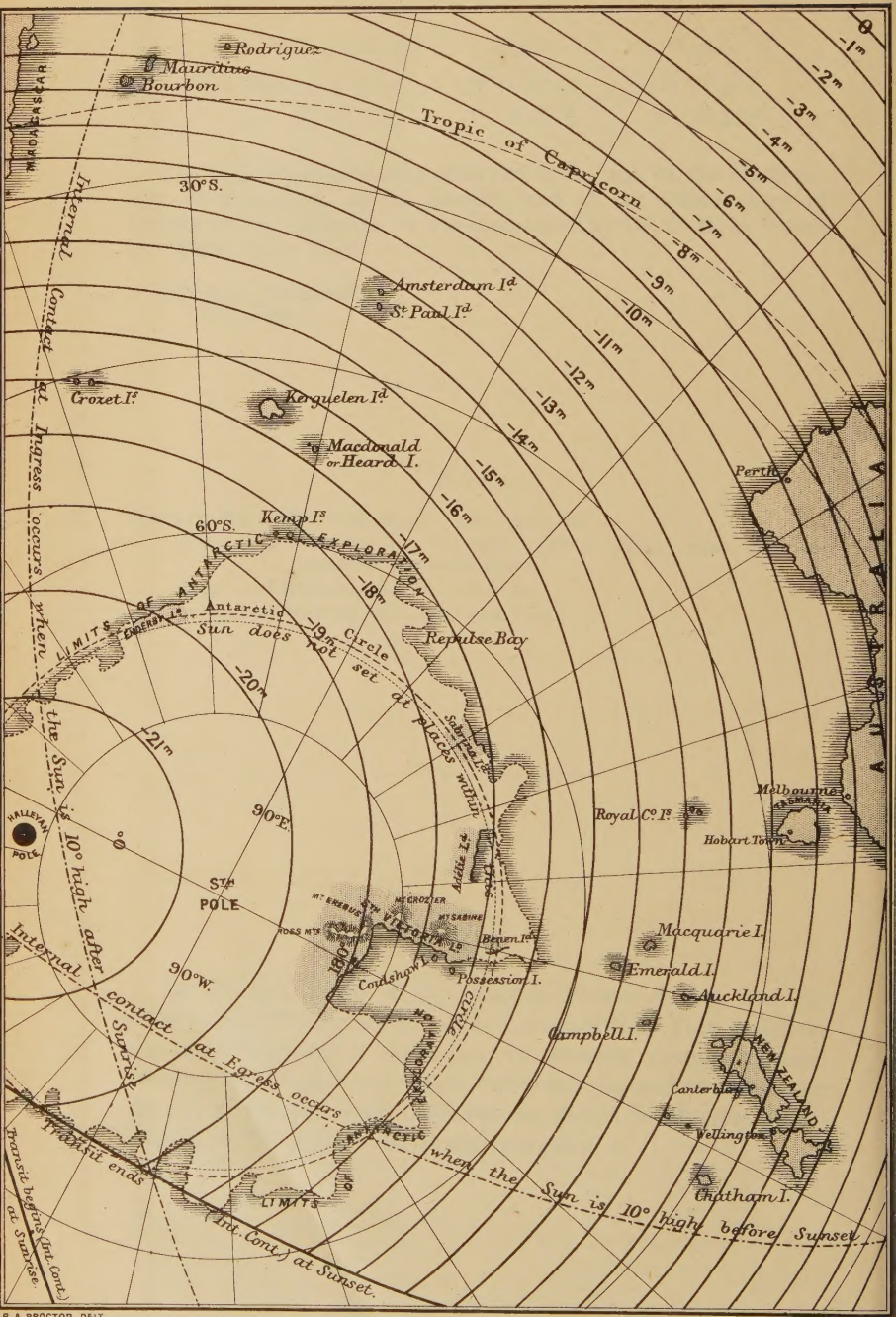
Page 417, line 15 from bottom, *for* 'our,' *read* 'an.'
418, 15 from top, *for* 'irregular meniscus figure,' *read* 'irregular (sphere + meniscus) figure.'
423, 18 from top, *for* 'us,' *read* 'as.'
423, 23 from top, *for* 'But,' *read* 'By.'

Notice.

Mr. Proctor, Editor of the *Monthly Notices*, having been invited by the Literary and Scientific Bureau of New York to deliver a course of Lectures on Astronomy in America, commencing next October, begs to give notice that letters and papers forwarded after the end of the first week in September should in all cases be addressed to Mr. Dunkin, Honorary Secretary.

TRANSIT OF VENUS IN 1874.

CHART OF THE ANTARCTIC AND SUBANTARCTIC REGIONS WHERE THE DURATION OF THE TRANSIT WILL BE SHORTENED.



R. A. PROCTOR, DELT.

MALBY & SONS, LITH.

-18m Signifies that the duration is 18m less than the Mean at all points along the curve so marked.